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सी एम एफ आर आइ
CMFRI

वार्षिक प्रतिवेदन
Annual report
2016 -17

As a side event to the Kochi-Muziris Biennale 2017, CMFRI erected an installation art at Fort Kochi beach for building public awareness on plastic pollution in the seas.

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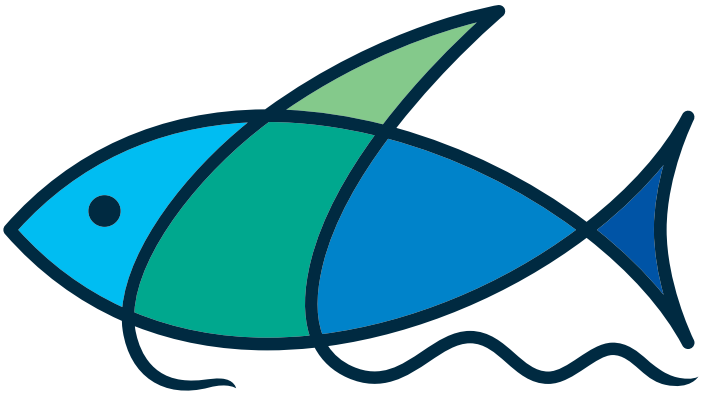
ANNUAL REPORT 2016-17



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CMFRI

Indian Council of Agricultural Research

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

ISO 9001:2008
Post Box No. 1603, Ernakulam North P.O., Kochi-682 018, Kerala, India
www.cmfri.org.in

CMFRI Annual Report 2016-2017

Published by
Dr A Gopalakrishnan
Director

Editorial team
Dr P Vijayagopal
Dr P Laxmilatha
Dr T V Sathianandan
Dr K S Sobhana
Dr Boby Ignatius
Dr S Lakshmi Pillai
Dr N K Sanil
Ms P Geetha

Software Support
Dr Mini K G
Manu VK

Event Photography
Mr P R Abhilash

Hindi Translation
Ms E K Uma

Installation art erected by CMFRI at Fort Kochi beach as part of the Kochi-Muziris Biennale 2017, for building public awareness on plastic pollution in the seas...
Kudos to team FEMD and Swachh Bharath Abhiyan of CMFRI for concept and execution. Cochin Shipyard for financial support.
Artists - Manoj Bramhamangalam, Pramod Gopalakrishnan, Antony Felix, Aji Kumar and Sanjay Ranjan Kartik

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Contents

Mandate

1

Monitor and assess the marine fisheries resources of the Indian Exclusive Economic Zone (EEZ) including the impact of climate and anthropogenic activity and develop sustainable marine fishery management plans

2

Basic and strategic research in mariculture to enhance production

3

Act as a repository of geospatial information on marine fishery resources and habitats

4

Consultancy services and human resource development through training, education and extension

Preface

CMFRI is the one and only research Institute in the country working towards the sustainable management of marine fisheries sector. Taking cognizance of the fact that the fish production from aquaculture equaled that fished from sea in the year 2015, for the first time in the history of global fish production, we gave equal emphasis to mariculture which may become the future of marine fish production. Our efforts in mariculture this year added to the marine food fish breeding technology, Indian pompano (*Trachinotus mookalee*), pig face bream (*Lethirnus lentjan*) and orange-spotted grouper (*Epinephelus coioides*). We expanded our cage culture portfolio to 1508 cages. We have also been entrusted with the drafting of the mariculture policy for India.

In the realm of marine fisheries, our pioneering efforts culminated in the notification of the National Policy on Marine Fisheries (NPMF) in the Gazette of India. Our inputs were recognised as the policy guidelines for regulating light fishing in the country. We are advising on revision of the Kerala Marine Fishing Regulation Act (KMFRA) for the Govt. of Kerala. Marine fisheries policies for the states of Karnataka, Goa and Andhra Pradesh are also being drafted by team CMFRI. We have also come out with an Indian Marine Fisheries Code which guides the establishment of a marine fisheries management model for India based on Food and Agriculture Organisation's (FAO's) Code of Conduct for Responsible Fisheries (CCRF).

Our Geographical Information System (GIS) inventory of marine fish landing centers in India was sought by Indian Navy whereby we contributed to the security of the nation also.

Clam fisheries are dear to us and we facilitated MSC certification which was a first for India and we are now trying to get some of our commercial fisheries also certified. We are also working on a restoration plan for the black clam fishery in the Vembanad Lake.

Sea ranching of 0.5 million *Penaeus semisulcatus* seeds was another major activity restarted at the behest of the Govt. of Tamil Nadu for augmentation of Mandapam flower shrimp fishery.

CMFRI publicly released the marine fish landing data for the year 2016 as in the earlier years indicating an overall increase of 6.6% over the previous year. It is customary for us to dwell into all the nuances in marine fish catch, effort and population dynamics.

We produced through our research another nutraceutical from the seaweeds, Cadalmin™ Antihypercholesterolemic extract (Cadalmin™ ACe) for dyslipidemia and obesity. This product was released in the inaugural function of the 70th anniversary celebrations of CMFRI by the Hon'ble Governor of Kerala, Justice P. Sathasivam on 18th February 2017. Similarly, another fish viral diagnostic product which is a β-nodavirus detection kit was released by the Director General of ICAR Dr. Triloachan Mohapatra on 18th April 2016. 'Fishliser' an organic fertilizer and 'Irrigateeasy', a micro irrigation kit suitable for irrigating kitchen gardens were notable outputs of our Krishi Vigyan Kendra (KVK) in the current year.

Our social scientists assessed the impact of demonetisation on the fisheries sector and we are monitoring fisheries trade and livelihood issues of fishers. Gross revenue and unit price of marine fish at the landing centre and in the market were regularly mornotored. Our Theeramythri and Theeranaipunya programmes in association with Department of Fisheries (DoF) and Society for Assistance to Fisherwomen (SAF) were well attended and received.

We received the Asian Fisheries Society gold medal for the successful conduct of the Cage Acuaculture 5 (CAA5) symposium in 2015. Drs. B. Johnson and Grinson George were bestowed with the Dr. Hiralal Chaudhary young scientist award instituted by Central Institute of Fisheries Education (CIFE) and best investigator award in the International Conference on 'Advances in Algal Biotechnology' held during 10-12 August 2016 at VIT University, Vellore respectively. Dr. Imelda Joseph's paper on cage farming was highly commended at the 11th Asian Fisheries and Aquaculture Forum 2016 at Bangkok.

We excelled in the Official Language implementation work leading to its recognition with Rajarshi Tandon Award instituted by the ICAR for the 7th time for the excellent Official Language implementation activities among the Institutes situated in 'C' Region, for the year 2014-15. We remained overall champions in ICAR South Zone Sports 2016 Meet (2nd time) and we were also recognised as one of the few Institutes in ICAR implementing cashless transactions.

Another outstanding recognition was the coverage in the Prime Ministers `man ki baat' about CMFRI teaming up with Tata Consultancy Services (TCS) in development of the Mobile App for fishers. The App helps to reduce scouting time for fishing by around 50% and reduce fuel consumption leading to increased profit to the tune of 25-35%.

Our research outputs were documented in 147 peer reviewed publications, 53 presentations in seminars and symposia, 11 technical manuals, 66 book chapters and popular articles, 11 books, 5 videos and 2 patents in the current year.

I thank team CMFRI for its constant pursuit to do better and the support of the subject matter division of ICAR

A. Gopalakrishnan
Director, CMFRI

Executive Summary

During the current year CMFRI operated 33 in-house research projects, 37 externally funded projects and 13 consultancy projects. This document chronicles that systematically.

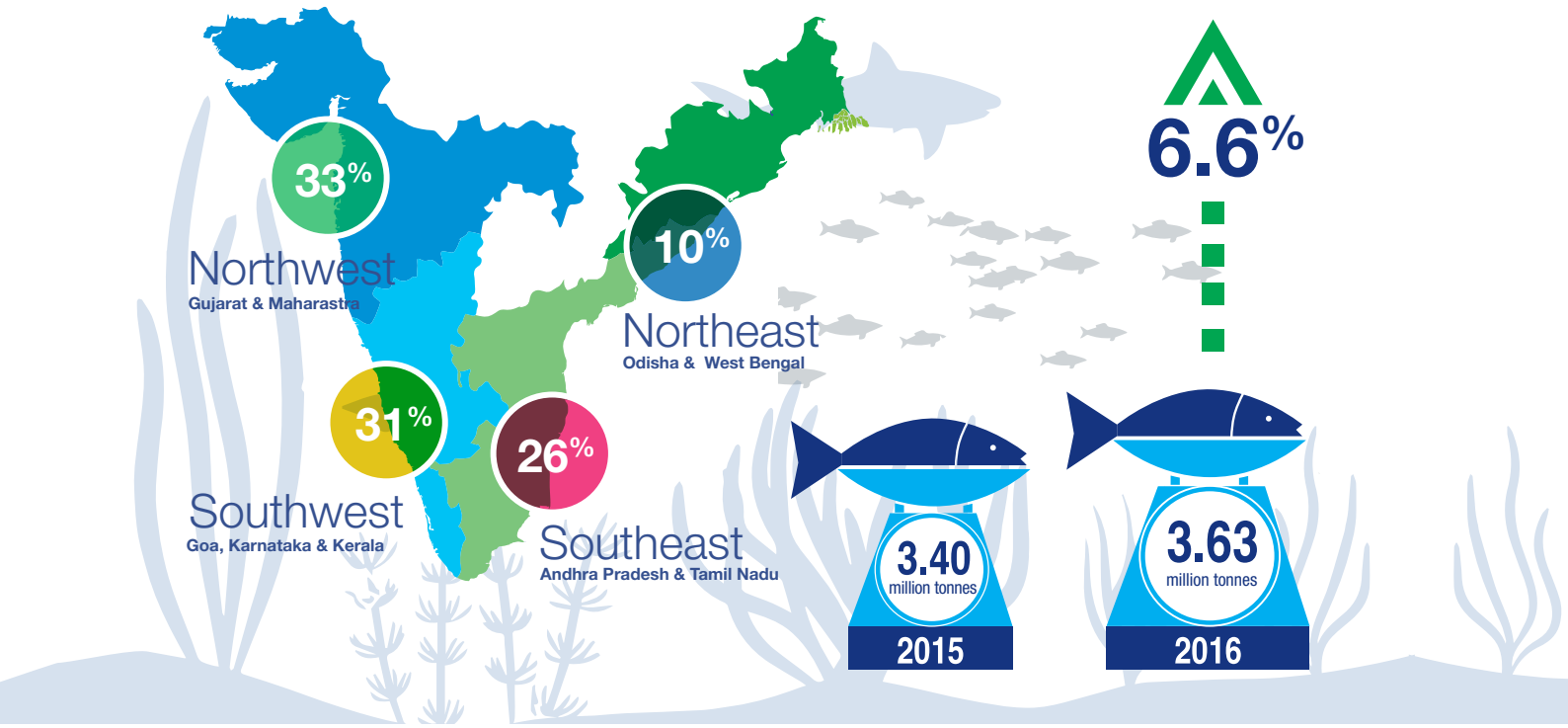
Marine fish landings in India were estimated as 3.63 million t during the year 2016 which is 6.6% more than the previous year. Gujarat tops the marine fish landings in India during 2016 for the fourth consecutive year. Indian mackerel the national fish of India became the highest contributor in 2016 with 2.49 lakh t. Declining trend of Indian oilsardine continued and it fell to 2nd position in the marine fish landing rankings during 2016. Hilsa shad, the favourite fish of West Bengal recovered from its pevious trends of dwindling landings to reach 94000 t which is a fourfold increase since last year. *Priacantus* spp. commonly known as bull's eye emerged as a major resource in the landings with high production along the west coast where Karnataka contributed the maximum. Cyclones affected fishing in Andhra Pradesh and Odisha resulting in poor catch due to loss of fishing days. Karnataka boosts its landings to cross 5 lakh t to become the third major fishing state in India during 2016.

The marine fisheries census data collected in February 2016 was digitised, which contains information from 882263 fisher households in 4057 villages. This is a statistical portrait of marine fisherfolk residing in the marine fishing villages of all the 9 maritime states and 2 union territories of India. This was also an exercise which gathered information regarding the fishing craft and fishing gears from 50 fishing harbours and 1281 fish landing centers in the country. A web application for online fishery data collection and transmission was also developed this year.

In fisheries and ecosystem modeling, estimation of stock status, maximum sustainable yield and optimum fishing effort for three resources namely oilsardine, mackerel and *Stolephorus* for the fishery in Kerala were done using multi-species stock assessment model, a multivariate version of Schaefer's model wherein the current biomass is expressed as a function of previous year biomass and catch. As per the attempted multispecies model, the maximum sustainable yield for the three resources in Kerala are 2.42, 1.10 and 0.45 lakh t.

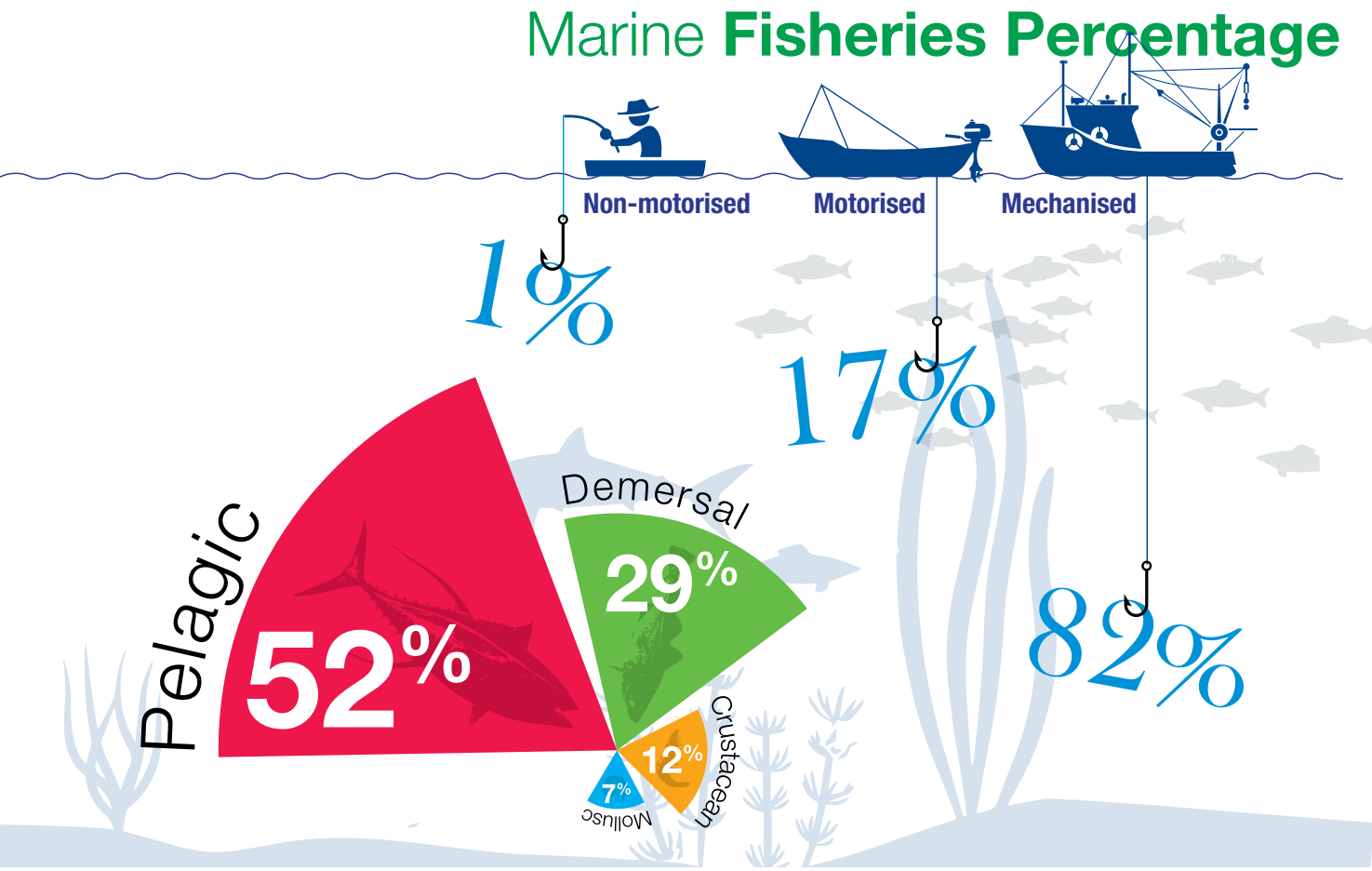
Marine **Fish Landings**

8129 km Coastline | **9** Maritime States | **2** Union Territories



Under the Chlorophyll based Remote-sensing Assisted Indian Fisheries Forecasting System (ChloRIFFS) programme, relationship between Chlorophyll concentration and marine aerosols in the northern Indian Ocean was studied and a data management system for ChloRIFFS was also developed. Optical classification of coastal waters of the Northern Indian Ocean was detailed. Ecosystem modeling for higher trophic level community to assess the impacts of overfishing upon food chain, was carried out using OSMOSE (Object-oriented Simulator of Marine ecoSystems Exploitation) model configured for the Kerala coastal region with prime focus upon two species namely *Trichiurus lepturus* and *Sardinella longiceps*. Fish distribution in response to oceanic forcing is another modeling exercise carried out. Eco-biological investigations on major pelagic fishes and ecological modeling of the epi-pelagic habitat off Kerala and Lakshadweep is another externally funded project in which GIS mapping of tuna advisories for the Lakshadweep group of islands was done. Nineteen locations identified by CMFRI have formed potential fishing zones (PFZ) for tunas as per the INCOIS advisories. In the project on GIS based resources mapping of distribution and abundance of finfishes and shellfishes off Indian Coast, the major output was a `Handbook on Application of GIS as a Decision Support Tool in Marine Fisheries". GIS based inventorying of 1278 marine fish landing centres of Indian coast was another output which was sought by Indian Navy. Other areas of work were mapping of resources, fishing operational areas as well as trawling grounds along Indian coast. Two other funded projects included modeling bio-geochemical cycles in coastal oceans and flow of matter through trophic levels and biogeochemical cycles in marine and estuarine ecosystem.

The findings in capture fisheries research projects are presented state-wise under the headings, Gujarat, Maharashtra, Karnataka and Goa, Kerala and Lakshadweep, Tamil Nadu and Pondicherry, Andhra Pradesh, trawl fishery of northeast coast of India, elasmobranchs, large pelagics, bivalve fisheries management and ornamental gastropod fisheries. The section



ends with the essence of the stake holder consultations conducted in various centers in these fisheries management plan (FMP) projects.

In the genetics and genomics projects, the complete mitochondrial sequence of Indian edible oyster *Crassostrea madrasensis* was elucidated. Population genetic structure of Indian anchovy *Stolephorus indicus* using mitochondrial DNA markers indicated panmixia. Studies on the mitogenome in the Indian oilsardine to find the environmental adaptations, indicated sympatry in all the ecotypes studied, supporting the conclusion that, metabolic divergence is a critical adaptation involved in Indian oilsardine subpopulation structuring. Microsatellite markers were developed for *Eleutheronema tetradactylum* (Indian salmon) using the next generation sequencing technology. Population genetic structure of *Lutjanus argentimaculatus* was studied using microsatellite markers. Taxonomic ambiguity in *Paphia malabarica* was resolved using molecular taxonomy and it was found to be genetically different from *Protapes gallus*. Similarly, molecular taxonomy studies were undertaken in *Gymnura poecilura* for species identification. A new species of mackerel *Somber indicus* was found genetically closer to *S. colias* followed by *S. japonicus*. Molecular basis of osmoregulation in sand lobsters exposed to different abiotic factors was studied. Development and testing of species specific mitochondrial DNA markers for larval identification of commercially important spiny lobster species and testing their efficiency in larvae was another aspect of lobster genomics looked into. Biofouling and comparative phylogeographic status of the barnacle *Chelonibia testudinaria* on various hosts from the Gulf of Mannar was studied to know the morphological variation is a case of host-specific phenotypic plasticity. Phylogenetics and evolution of bioluminescent organ systems in the ponyfishes (Family: Leiognathidae) from Indian coast was another area of work done. Diet analysis using molecular markers in commercially important tunas indicated substantial consumption of fishes by yellowfin tuna. Cannibalism has also been indicated in yellow fin tuna. Hepcidin, a cysteine rich anti-microbial peptide with multiple isoforms in fishes with important role

in immune defense was characterised in the grouper, *Epinephelus diacanthus*. Genes related to growth and metabolism was amplified and characterised in silver pompano, *Trachinotus blochii* and red snapper, *Lutjanus argentimaculatus*.

In the area of cell and tissue culture, a protocol for inducing nacre layer formation on nuclear beads under *in vitro* conditions using cultured granulated epithelial cells from mantle tissue of black-lip pearl oyster *Pinctada margaritifera* was developed. Derivation and characterisation of embryonic stem (ES) cell lines from the marine ornamental maroon clown fish *Premnas biaculeatus* and induced pluripotent stem (iPS) cell lines from the humpback grouper, *Cromileptes altivelis* was also undertaken.

In fish nutrition, lipid requirement in feeds of pompano was delineated as 6 - 6.38%. Fucoidan a sulphated polysaccharide from brown seaweeds administered through feeds elicited both immuno modulatory and antibacterial activity in cobia. In the marine ornamental fish *Amphiprion ocellaris,* paprika, curcumin and chlorophyll oleoresins enhanced colour. Similarly, *Porteria hornemannii* a red seaweed incorporated feed enhanced colour in *Amphiprion sanadaracinos*. Fatty acid composition of microalgae were profiled and extracelluar lipase was purified from gammaproteobacterim KX272637. Nutritional qualities of cephalopods were profiled. In lobster nutrition, fattening feeds were evaluated in spiny lobsters and micro-bound diets were developed and evaluated in sand lobster larvae.

In the area of fish health management, pathogen profiling in food fish and ornamental fish continued. Two new species of myxosporeans, *Ceratomyxa collarae* n. sp. and *Ceratomyxa leucosternoni* n. sp. reported from marine ornamental fishes of Indian waters. A new species of acanthocephalan parasite, *Filisoma keralensis* n. sp. infecting the intestine of *Scatophagus argus* was discovered and described. Bacterial infection in cage farms were studied. Dual infection with *Vibrio harveyi* and two strains of *Photobacterium damselae* ssp. *damselae* was studied, where the vibrios could be managed with probiotics. Nervous Necrosis Virus (NNV) infection in cage cultured sea bass at Karwar was diagnosed using “ß-Nodadetect” a RT- LAMP based diagnostic kit developed by CMFRI. Density and diversity of cultivable bacterial assemblages associated with haemolymph and tissues (gut, gill, mantle and muscle) of apparently healthy green mussels (*P. viridis*) were studied. Health monitoring of broodstock and larvae of lobsters and Indian halibut was continued, infestation with carcinonemertan worms were frequently observed in berried female lobsters at Chennai. Under the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD), regular screening of wild and farmed bivalves for OIE listed pathogens were carried out along the east and west coasts of India including Lakshadweep and Andaman islands. In the all India network project on fish health, information regarding products used in aquaculture were collected through a questionnaire based survey.

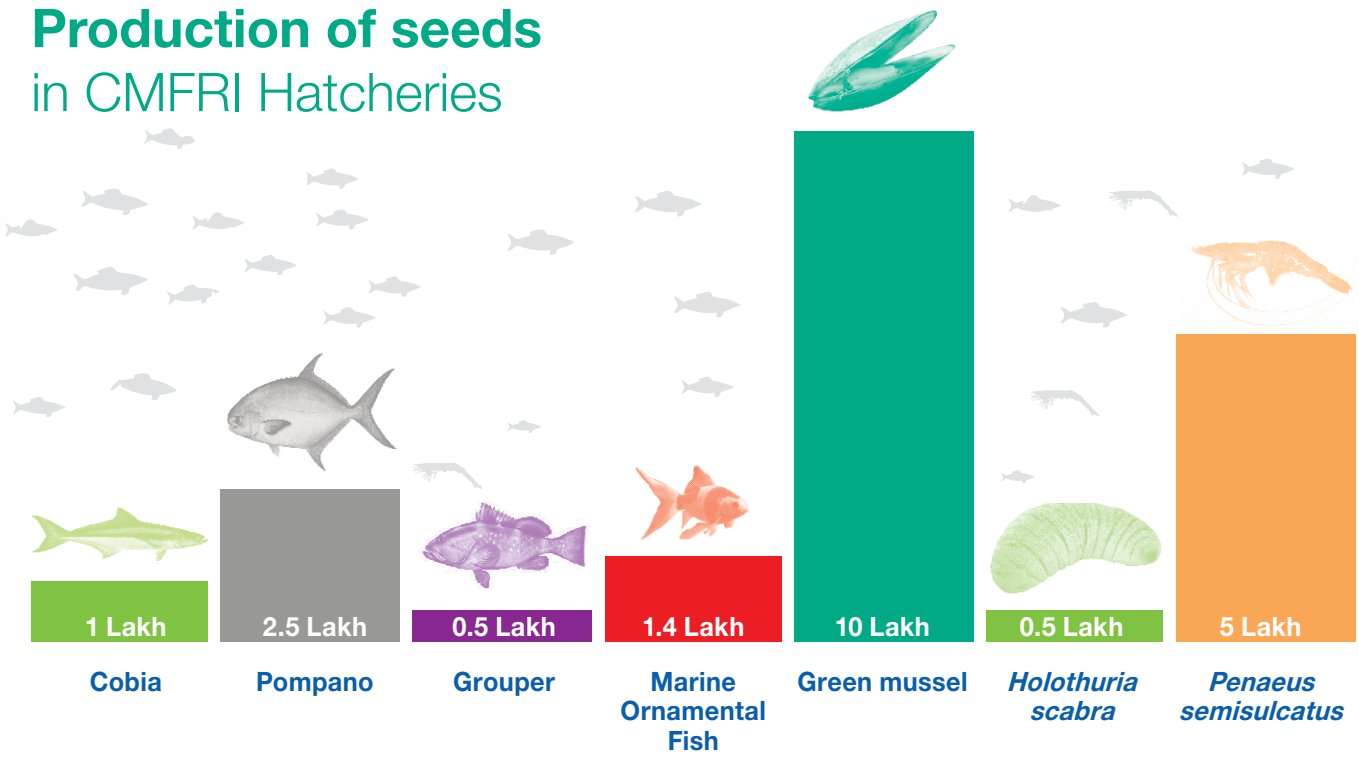
In marine bioprospecting, Cadalmin™ Antihypercholesterolemic extract (ACe) a nutraceutical product was developed from seaweeds. Bioactive pharmacophore leads from the product inhibit hydroxymethyl glutaryl coenzyme A reductase, various target receptors and other rate limiting enzymes, which are responsible to cause obesity and dyslipidemia. Justice P. Sathasivam, Hon’ble Governor of Kerala, released the product at ICAR-Central Marine Fisheries Research Institute in Kochi on 18th February 2017. An antimicrobial therapeutic product was developed from the seaweed associated bacterium. An anti-inflammatory pharmacophore-encapsulated, seaweed derived hybrid drug delivery system was assessed for oral drug delivery and topical application. The antibacterial potential of seaweed associated gamma proteobacterium was evaluated. Fucoidan possessing antibacterial and immunostimulant properties was extracted from brown seaweeds. Bio-prospecting of bacterial isolates from different marine sources for the presence of commercially significant enzymes were carried out. Antibacterial pharmacophores from marine bacterium *Bacillus subtilis* associated with seaweed *Sargassum myriocystum* were studied. Two rare antioxidant and anti-inflammatory oleanenes from loop root Asiatic mangrove *Rhizophora mucronata* were charecterised. Biogenic guaianolide-type sesquiterpene lactones with antioxidative and anti-inflammatory properties from natural mangrove hybrid *Rhizophora annamalayana* were isolated and charecteised. The potential

of seaweeds as natural alternatives to synthetic antioxidants in preventing rancidity of refined fish oil for use in food and pharmaceutical industries was also demonstrated. Unprecedented antioxidative and anti-inflammatory aryl polyketide pharmacophore leads from *Sargassum wightii* were discoverd. Antioxidant and antihypertensive potential of sulfated polygalactans isolated from the marine macroalgae *Kappaphycus alvarezii* and *Gracilaria opuntia* were assessed by utilising different *in vitro* systems.

In the mariculture research front, mass scale production of orange spotted grouper (*Epinephelus coioides*) with 20% survival leading to seed distribution for farming along with Indian pompano (*Trachinotus mookalee*) seeds was the highlight. Success in seed production of bream *Lethrinus lentjan* was also a breakthrough. Successful broodstock development and larval rearing of marine ornamental camel shrimp and mass production of hybrid percula clownfish (Picaso & Platinum) was achieved. Mass production protocols for three promising species of calanoid copepods *Acartia spinicauda*, *Temora turbinata* and *Pseudodiaptomus serricaudatus* strengthened our larval nutrition portfolio. The average annual seed production figures are cobia - 1 lakh; pompano - 2.5 lakhs (both ~15 cm); grouper - 50,000, an array of 14 marine ornamental fish species - 1.4 lakhs, green mussel - 10 lakhs; *Holothuria scabra* - 50,000 and P*enaeus semisulcatu*s - 5 lakhs. We witnessed large scale adoption of farming technology by SHGs in all maritime states with the total number of cages installed with the technical help of CMFRI rising to 1508. Apart from this, trial production of blue swimmer crablets were initiated recording a survival of 10%. Trial farming of these crabs at Vedalai Village, Ramanathapuram District in participatory mode with fishermen group has also been initiated.

We recorded losses in farmed mussels with mortality rates to the tune of 90%. A multi-disciplinary team investigated the crisis in 2016 and a report was submitted to the Govt. of Kerala in October 2016. The key issues were identified and 21 recommendations have been made which includes farm registration and licensing practices to be followed by the Department of Fisheries (DOF) in collaboration with the local Panchayats. The number of farm units has to be reduced by 20%. This report was also presented on 15th October, 2016 to nearly 200 farmers and agents. Even though, farmers agreed with the recommendations, action from DOF Kerala is awaited.

Production of seeds
in CMFRI Hatcheries



Bioinventorying and biodiversity valuation of marine organisms in selected marine ecosystems along the Indian Coast was estimated from nine districts of Kerala using the standard methodologies. Provisional services like fisheries, aquaculture and agriculture together forms about ₹1300440 ha^{-1} yr^{-1} ($28899 ha^{-1} yr^{-1}). Biodiversity assessment of Gulf of Mannar and valuation of Karnataka coastal ecosystem were carried out. For the formulation of management measures for conservation of coral reef ecosystems in Indian waters, coral diversity, fish assemblage, and other bioresources associated with coral reefs of Grande island, Gulf of Kutch, Goa, Palk Bay Tuticorin Major Harbour and Androth, Kalpeni and Bitra islands of Lakshadweep were investigated. In the propagation studies on soft corals, growth of soft coral *Cladiella laciniosa* in laboratory conditions was examined. Propagation studies on soft coral *Sinularia kavarattiensis* was done at Calicut. In the assessment and valuation of coral reef island ecosystem, biodiversity of Devagad Island was studied which included the valuation of Devagad Island ecosystem. Molecular taxonomy and phylogeny of cones (cone snails) and strombs (mollusca, gastropoda) of the Indian coast were studied in an externally funded project.

In the thematic area of marine habitats, investigations on marine litter in fishing area and fishing gears and beach litter was quantified taluk-wise in Kerala. Impact of litter on critical habitats like mangroves and seagrass and occurrence of macroplastics in fish gut and marine oil pollution in general were studied. Studies on the fly ash deposition rate in the Karapad Bay, Tuticorin and impact of untreated municipal sewage were also facets added to these studies. In the project on ecosystem process of critical marine habitats and development of protocols for restoration, eco-biological processes of mud banks of Kerala, *Noctiluca* spp. blooms along west coast were studied and documented. Inter-relations between abiotic factors and phytoplankton during post-monsoon period were critically examined. Ecology of seagrass beds, restoration of mangroves, sentinel site monitoring in Nethravathi Estuary and monitoring of coastal and sea birds also formed a part of these studies. Ecological variations in sardine habitats and its impact on sardine fishery in Kerala is a major work that attracted public attention. Resource assessment, exploitation and utilisation of marine algae from Indian coasts is another research project providing inputs to the assessment of marine resources. Studies on enhancing the effectiveness of conservation potential of marine mammals in Indian seas is another area of work focused on.

To create awareness among the public on the colossal threat created by marine litter to ecosystem, CMFRI in collaboration with Cochin Shipyard, developed an installation art entitled "Fish Cemetery" covering an area of 2500 sqft with a height of 13 ft at south beach, Fort Kochi. This creation was done by artists Mr Manoj Brahmamangalam and Mr Pramod Gopalakrishnan along with Mr. Antony Felix, Mr. Aji Kumar, Mr. Sanjay Ranjan Kartik with funding from Cochin Ship Yard Ltd.

Climate change and its impact on marine fisheries come under the National Innovations on Climate Resilient Agriculture (NICRA) programme of ICAR. In capture fisheries, vulnerability assessment, carbon stock assessment of mangroves, climate modeling and changes in distribution and community structure of zoanthids, maturity and spawning studies, changes in phytoplankton community in relation to SST and sardine abundance and life cycle assessments were worked upon. In mariculture, carbon sequestration potential of seaweeds, identification of climate resilient species for mariculture, technology demonstrations in cage culture and Integrated Multi Trophic Aquaculture (IMTA) were the activities. Vulnerability assessment for at risk coastal fishing communities-ultimately forming the Integrated District Level Adaptation and Mitigation (IDLAM) framework to combat the deleterious effects of climate change was also undertaken.

In the valuation of marine fish landings, economic performance and supply chain management, the estimated value of marine fish landings during 2016 at landing Centre level was ₹48,381 crores (20.7% increase over 2015) and at retail level, realised ₹73,289 crores (12.4% increase over 2015). The unit price per kg of fish realised at landing centre was ₹133.4, (13.2% increase over 2015) and at the retail market level was ₹201.9 (5.46% increase over 2015).

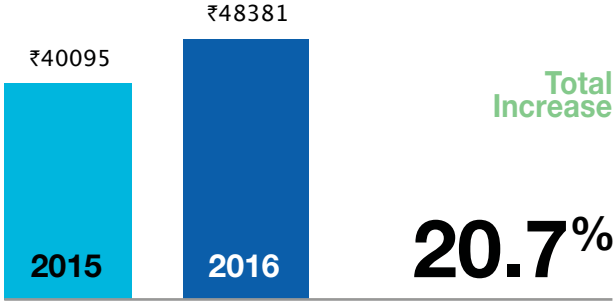
Species-wise share in quantity and sales (%), State-wise valuation across the value chains, state-wise valuation of marine fish landings, gross valuation of inventories in marine fisheries

sector were also documented. Macro indicators of marine fisheries sector in India, economic performance of fishing methods, fish arrival to Kerala, impact of demonetisation in domestic fish trade and consumption were also recorded. In the international project on Global understanding and learning for local solutions (GULLS), socio-economic vulnerability assessments were carried out and a conceptual framework for assessing coastal community vulnerability was developed.

In fishery governance, livelihood gender and welfare research, impact assessment of the capacity development tools was done. Livelihood effects of closed fishing season and their impact on resource use in Kerala were studied with funding from Michigan State University, USA. In the area of gender mainstreaming in marine fisheries sector, performance appraisal of Theeramythri initiatives in Kerala was done with the objective of benefit monitoring assessment and visioning for the future. Attributes of successful group was done by analysing coherence among the group members. CMFRI has developed a book of accounts called TIMES register (Theeramythri Information on Monitoring and Evaluation System) for transparency in their transactions. In Theeranaipunya-II, skill enhancement and capacity building of fisher youth was taken up through a two month capacity building training programme for 35 educated unemployed young fisherwomen, which was funded by the Society for Assistance to Fisherwomen (SAF). Status of Fisheries Insurance in India was a new area under our assessment. Through the Agriculture Technology Information Centre (ATIC) which function jointly with KVK sales counter, revenue generated was ₹346286.

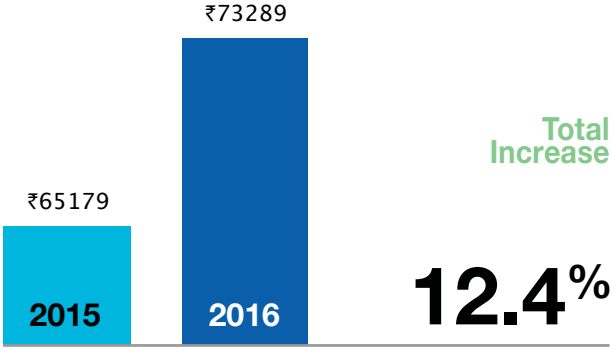
State-wise landing centre value
in ₹crores and % variation with 2015

Kerala	₹ 9149	-4.4%
Gujarat	₹ 8427	19.9%
Tamil Nadu	₹ 6492	15.2%
Karnataka	₹ 6247	35.3%
Odisha	₹ 1645	-33.7%
Maharashtra	₹ 5369	16.1%
Andhra Pradesh	₹ 2516	-17.5%
West Bengal	₹ 5501	350.9%
Goa	₹ 997	-5.9%
Daman & Diu	₹ 1433	131.1%
Puducherry	₹ 605	218.4%



State-wise retail centre value
in ₹crores and % variation with 2015

Kerala	₹ 12398	-15.3%
Gujarat	₹ 13130	12.2%
Tamil Nadu	₹ 10728	11.2%
Karnataka	₹ 9108	18.4%
Odisha	₹ 2836	-29.5%
Maharashtra	₹ 8313	10.9%
Andhra Pradesh	₹ 3916	-18.9%
West Bengal	₹ 8190	425%
Goa	₹ 1451	-32.5%
Daman & Diu	₹ 2351	120.4%
Puducherry	₹ 868	128.4%



कार्यकारी सारांश

चालू वर्ष के दौरान सी एम एफ आर आइ द्वारा 32 गृहांदर अनुसंधान परियोजनाओं, 30 बाहरी वित्त पोषित और 12 परामर्श परियोजनाओं का संचालन किया गया. इस दस्तावेज में इन सभी का व्यवस्थित रूप से वर्णन किया गया है.

भारत में समुद्री मछली अवतरण वर्ष 2016 के दौरान 3.63 मिलियन टन आकलित किया गया था, जो पिछले वर्ष की अपेक्षा 6.6% अधिक है. लगातार चार वर्षों से वर्ष 2016 के दौरान भी गुजरात समुद्री मछली अवतरण में भारत में सबसे आगे रहा. वर्ष 1996 से लेकर भारतीय बांगडा, जो भारत की राष्ट्रीय मछली है, का सबसे अधिक अवतरण किया गया था और वर्ष 2016 में भी 2.49 लाख टन का अधिकतम अवतरण आकलित किया गया. तारली के अवतरण में कमी की प्रवणता जारी रही और वर्ष 2016 के दौरान भी समुद्री मछली अवतरण में द्वितीय स्थान पर रही. पिछले वर्षों के दौरान पकड़ में हुई कमी को पार करते हुए हिल्सा शाड, जो पश्चिम बंगाल की पसंदीदा मछली है, का अवतरण 94,000 टन आकलित किया गया, जो पिछले वर्ष की अपेक्षा चार गुना अधिक है. *प्रियाकांथस* प्रजाति, जिसे सामान्यतः बुल्सआइ कहा जाता है, पश्चिम तट के अवतरण की प्रमुख मछली है और कर्नाटक में इस मछली का अधिकतम अवतरण हुआ. आंध्रा प्रदेश और ओड़ीषा में चक्रवात की वजह से मत्स्यन दिन कम होने के कारण मछली पकड़ बहुत कम आकलित की गयी. वर्ष 2016 के दौरान कर्नाटक के मछली अवतरण में वृद्धि हुई और पांच लाख टन के मछली अवतरण के साथ भारत में प्रमुख मत्स्यन राज्यों में तृतीय स्थान पर रहा. इस वर्ष ऑनलाइन द्वारा मात्स्यिकी आंकड़ा संग्रहण और हस्तांतरण के लिए वेब एप्लिकेशन विकसित किया गया.

फरवरी, 2016 के दौरान संग्रहित समुद्री मात्स्यिकी जनगणना के आंकड़ों को डिजिटाइस किया गया है और इनमें 4057 गाँवों के 8,82,263 मछुआरा परिवारों की सूचना सम्मिलित की गयी है. यह भारत के 9 समुद्रवर्ती राज्यों और 2 संघ राज्य क्षेत्रों के समुद्री मत्स्यन गाँवों में रहने वाले मछुआरों का सांख्यिकीय चित्र दर्शाता है. इसके अतिरिक्त यह देश के 50 मत्स्यन बंदरगाहों और 1281 मछली अवतरण केन्द्रों के मत्स्यन यानों और गिअरों से संबंधित सूचना संग्रहित करने का प्रयास भी है.

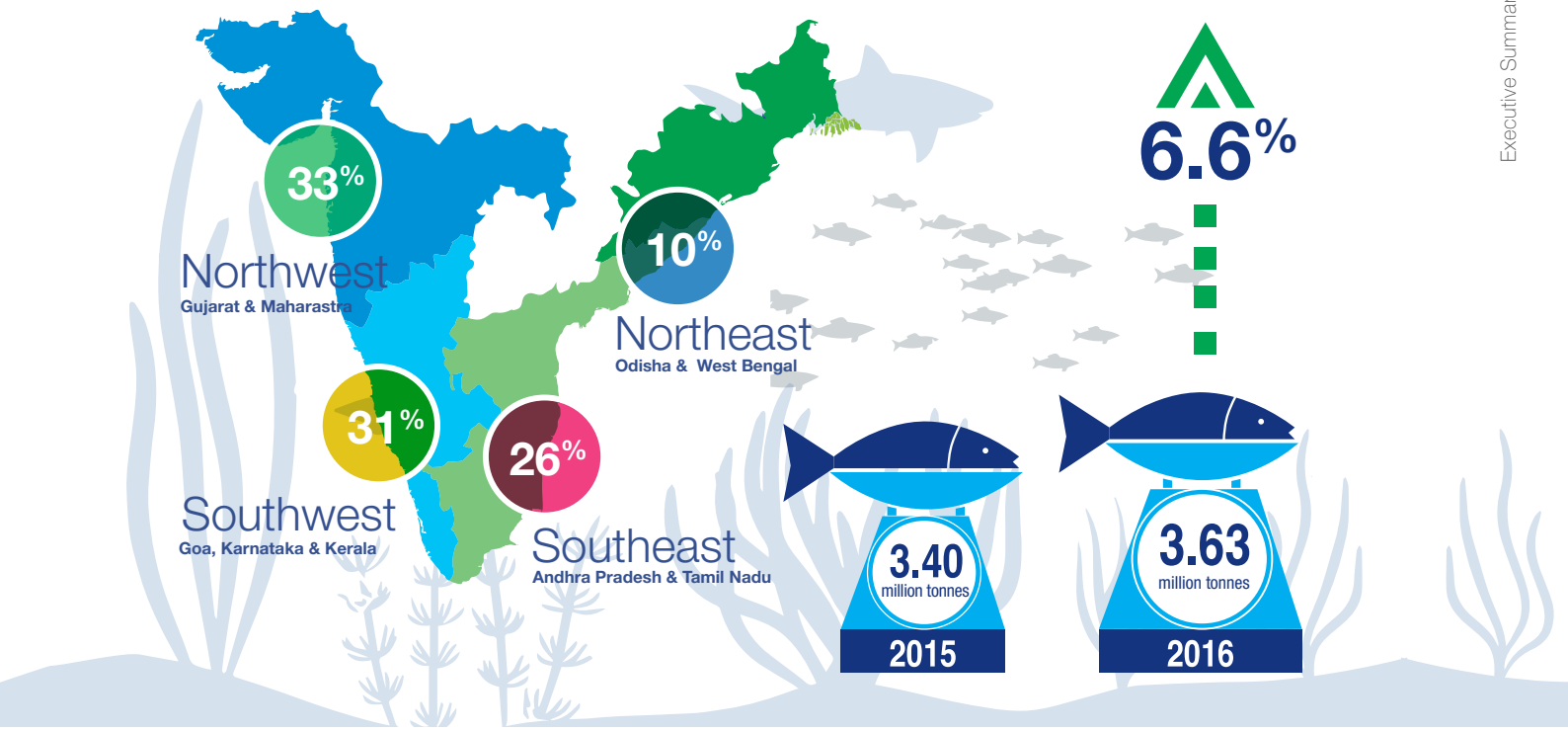
मात्स्यिकी एवं पारिस्थितिकी तंत्र प्रतिमान में, केरल की मात्स्यिकी के लिए बहु प्रजाति स्टॉक निर्धारण प्रतिमान, जिसमें चालू जैवभार को पिछले वर्ष के जैवभार के कार्य के रूप में व्यक्त करने वाले शीफेर्स प्रतिमान का बहुविविधता वाली वेर्शन है, के उपयोग से तारली, बांगड़ा और स्टोलिफोरस नामक तीन संसाधनों के प्रभव की स्थिति, अधिकतम वहनीय प्राप्ति और इष्टतम मत्स्यन प्रयास का आकलन किया गया. प्रयास किए गए बहुप्रजातीय प्रतिमान के अनुसार केरल के तीन संसाधनों की अधिकतम टिकाऊ प्राप्ति 2.42, 1.10 और 0.45 लाख टन आकलित की गयी.

क्लोरोफिल आधारित दूर संवेदन से समर्थित भारतीय मात्स्यिकी पूर्वानुमान व्यवस्था (ChloRIFFS) में उत्तर हिन्द महासागर की पर्णहरित सांद्रता और समुद्री ऐरोसोल्स के बीच के संबंध पर अध्ययन किया गया और ChloRIFFS के लिए आंकड़ा प्रबंधन व्यवस्था विकसित की गयी. उत्तर हिन्द महासागर के तटीय समुद्र के ओप्टिकल वर्गीकरण का विवरण दिया गया और खाद्य श्रृंखला में से अतिमत्स्यन के प्रभाव का निर्धारण करने हेतु केरल के तटीय क्षेत्र की दो प्रमुख प्रजातियों जैसा कि *ट्राइक्यूरस लेप्ट्यूरस* और *सारडिनेल्ला लोंगिसेप्स* के लिए कॉन्फिगर किए गए प्रतिमान ओ एस एम ओ एस ई (ओब्जेक्ट ओरिएन्टड सिमुलेटर ऑफ मराइन इकोसिस्टम्स एक्प्लोइटेशन) के उपयोग से उच्चतर पौष्टिकता स्तर जीवसंख्या का पारिस्थितिक प्रतिरूपण किया गया. महासागरीय फार्सिंग की प्रतिक्रिया में मछली वितरण का आकलन इस दौरान किया गया एक और प्रतिमान प्रयास है. केरल और लक्षद्वीप की प्रमुख वेलापवर्ती मछलियों पर पारिस्थितिकी-जैविक जांच और उप-वेलापवर्ती आवास तंत्रों के आवासीय मोडलिंग बाहरी वित्त पोषित दूसरी परियोजना है, जिसके अंतर्गत लक्षद्वीप समूह के ट्यूना परामर्श का जी आइ एस मानचित्रण किया गया. आइ एन सी ओ आइ एस परामर्शों के अनुसार सी एम एफ आर आइ द्वारा पहचान किए गए 19 स्थानों को ट्यूना के शक्य मत्स्यन क्षेत्रों (पी एफ इज़ेड) के रूप में परिवर्तित किया गया. भारतीय तट की पख मछलियों और कवच मछलियों के वितरण एवं प्रचुरता पर जी आइ एस पर आधारित संसाधन मानचित्रण विषयक परियोजना के अंतर्गत "समुद्री मात्स्यिकी में निर्णय समर्थन उपाय के रूप में जी आइ एस के प्रयोग पर हैन्डबुक" प्रमुख सफलता थी. भारतीय तट के 1278 समुद्री मछली अवतरण केन्द्रों कर जी आइ एस आधारित सूचीकरण एक और सफलता निकली जिसकी भारतीय नौ सेना द्वारा मांग की गयी. अन्य कार्य क्षेत्र, संसाधन मानचित्रण के लिए नयाचार विकास और मत्स्यन परिचालन क्षेत्र का मानचित्रण, संसाधन मानचित्रण और मत्स्यन परिचालन क्षेत्र का मानचित्रण तथा भारतीय तट के चारों ओर के आनाय क्षेत्र का मानचित्रण थे. अन्य दो निधिबद्ध परियोजनाएं तटीय महासमुद्रों में बयो-जियोकेमिकल साइकिल का प्रतिमान तथा फ्लो ऑफ मैटर थ्रू ट्रोफिक लेवल्स और समुद्री एवं नदीमुख आवास तंत्रों में बयो-जियोकेमिकल साइकिल थीं.

प्रग्रहण मात्स्यिकी के अनुसंधान कार्यों का विवरण गुजरात, महाराष्ट्र, कर्नाटक एवं गोवा, केरल एवं लक्षद्वीप, तमिल नाडु एवं पोंडिचेरी, आंध्रा प्रदेश, भारत के उत्तर पूर्व तट की आनाय मात्स्यिकी, उपास्थिमीन, बड़े वेलापवर्ती, द्विकपाटी

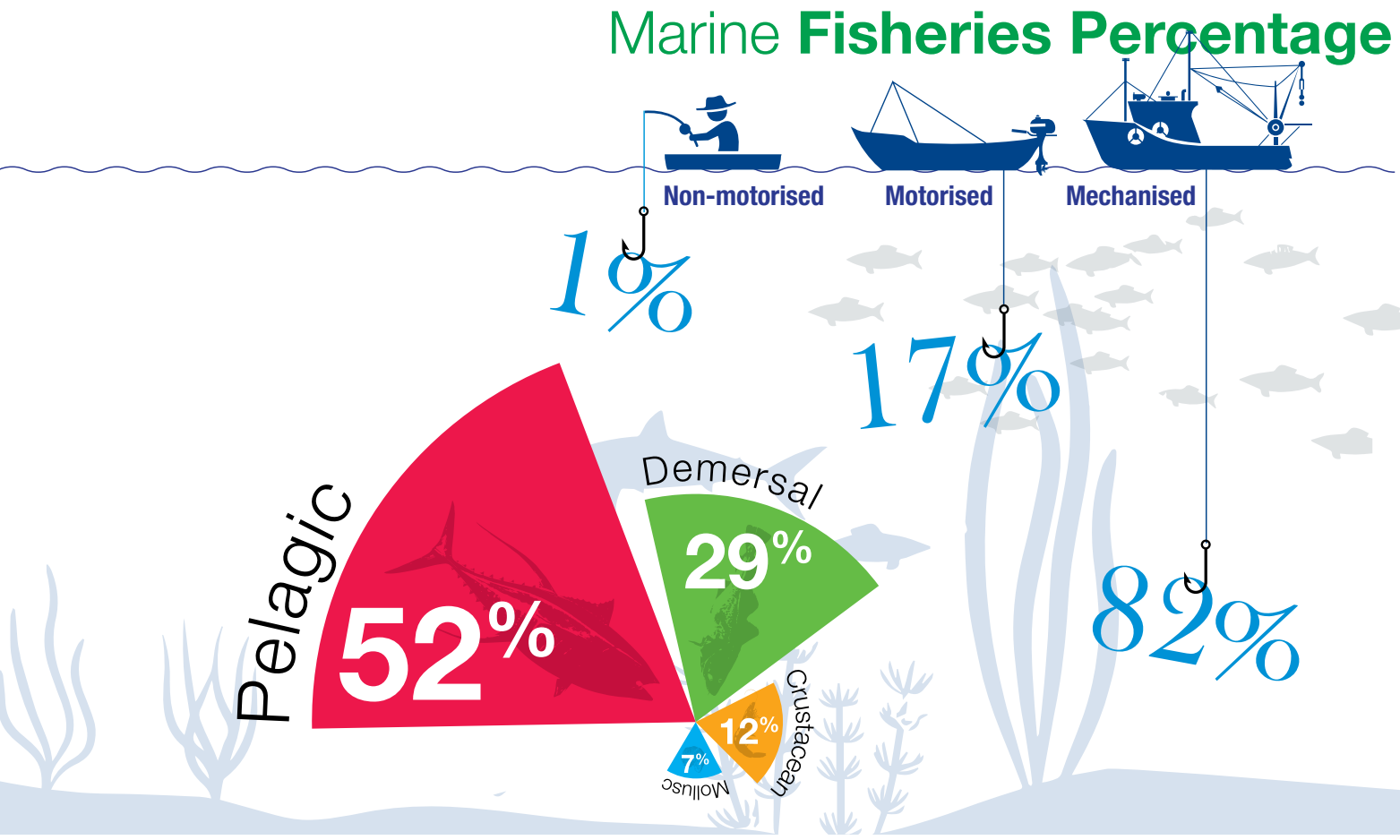
Marine **Fish Landings**

8129 km Coastline | **9** Maritime States | **2** Union Territories



मात्स्यिकी प्रबंधन और अलंकारी जठरपाद मात्स्यिकी आदि शीर्षकों के अंतर्गत राज्यवार स्तर पर दिया गया है. इन मात्स्यिकी प्रबंधन योजना (एफ एम पी) परियोजनाओं के संदर्भ में विभिन्न केन्द्रों में आयोजित हितधारकों की परामर्श बैठकों के साथ यह खंड समाप्त होता है.

आनुवंशिकी एवं जीनोमिक्स परियोजनाओं में, भारतीय खाद्य शुक्ति क्रासोस्ट्रिया माड्रासेन्सिस का पूरा माइटोकोन्ड्रियल अनुक्रम स्पष्ट किया गया. माइटोकोन्ड्रियल डी एन ए मार्कर के उपयोग से भारतीय ऐंचोवी स्टोलिफोरस इंडिकस की जीव संख्या आनुवंशिकी संरचना करने पर पानमिक्सिया का संकेत प्राप्त हुआ. भारतीय तारली के पर्यावरणीय अनुकूलनों के माइटोजीनोम पर अध्ययन करने पर, अध्ययन किए गए सभी इकोटाइपों में एसएमपाट्री पाया गया, जिससे यह समर्थन हुआ कि भारतीय तारलियों के उप जीव संख्या संरचना में चयापचय विचलन महत्वपूर्ण अनुकूलन देखा गया. अगली पीढ़ी के अनुक्रमण प्रौद्योगिकी के प्रयोग से एल्यूथ्रोनीमा टेट्राडक्टाइलम (भारतीय साल्मन) के माइक्रोसाटलाइट मार्कर विकसित किए गए. माइक्रोसाटलाइट मार्कर उपयुक्त करके लूटजानस अर्जेन्टिकाक्युलेटस की जीव संख्या आनुवंशिकी संरचना का अध्ययन किया गया. आण्विक वर्गिकी विज्ञान उपयुक्त करके पाफिया मलबारिका में होने वाली वर्गीकरण संबंधी अस्पष्टता हल कर दिया गया और यह प्रोटापेस गल्लस से आनुवंशिक दृष्टि से विभिन्न पायी गयी. इसी तरह, जिमनूरा पोसिल्यूरा में प्रजाति पहचार के लिए आण्विक वर्गीकरण का अध्ययन किया गया और *एस.कोलियास* और *एस.जापोनिकस* की निकट आनुवंशिक समानता होने वाली बांगडे की नयी प्रजाति *सोम्बर इंडिकस* पायी गयी. विविध अजैविक कारकों से परीक्षित रेती महाचिंगटों में ओस्मोरेगुलेशन के आण्विक आधार पर अध्ययन किया गया. वाणिज्यिक प्रमुख शूली महाचिंगट प्रजातियों के डिंभकों की पहचान के लिए प्रजाति विशेष माइटोकोन्ड्रियल डी एन ए अंककों का विकास और परीक्षण किया गया और डिंभकों में इनका परीक्षण करना महाचिंगट जीनोमिक्स की अगली पहलू है. दोनों जीवों में आकारमितीय विभिन्नता जानने के लिए मन्नार खाड़ी में विविध जीवों पर बर्नकिल *चीलोनिबिया टेस्टुडिनेरिया* के जैव अवरोध और तुलनात्मक फाइलोवियोग्राफिक स्तर का अध्ययन किया गया. भारतीय तट की पॉनीफिशों (कुटुम्बः लियोग्नाथिडे) की बायोलुमिनिसेन्ट अवयव प्रणाली का अध्ययन और एक अनुसंधान कार्य था. वाणिज्यिक प्रमुख ट्यूना मछलियों में आण्विक अंककों के प्रयोग से आहार विश्लेषण करने पर येलोफिन ट्यूना द्वारा इन मछलियों का व्यापक तौर पर खपत का संकेत मिला. येलोफिन ट्यूना में मांस भक्षिता का संकेत भी प्राप्त हुआ. ग्रूपर, *एपिनिफेलस ड्याकांतस* में हेप्सिडिन, जो मछलियों की प्रतिरक्षा रक्षा में प्रमुख भूमिका होनेवाले बहु आइसोफोम्स सहित सिस्टीन समृद्ध प्रति सूक्ष्माणु पेप्टाइड है, की विशेषता पायी गयी. सिल्वर पोम्पानो *ट्रकिनोटस ब्लोची* और रेड स्नाप्पर *लूटजानस अर्जेन्टिमाक्युलेटस* में वृद्धि और चयापचयन से संबंधित जीन का प्रवर्धन और विशेषता देखे गए.



कोशिका और ऊतकसंवर्धन के क्षेत्र में नाभिकीय माणिकों पर नेकर स्तर गठन के उत्प्रेरण हेतु संवर्धित दानेदार एपिथिलयमी कोशिकाओं का कृत्रिम परिवेशीय परिस्थितियों में प्रयोग कर कृष्ण ओष्ठ वाली मोती सीप *पिन्क्टाडा मार्गारिटीफेरा* के प्रावार ऊतकों से प्रोटोकोल विकसित किया गया. समुद्री अलंकारी लाल क्लाउन मछली *प्रेम्नास बायक्युलिटियस* में भ्रूण ऊतक (ईएस) की सेल लाइनों की व्युत्पत्ति एवं लक्षण वर्णन तथा कूबड़ वाली ग्रूपर मछली *क्रोमिलेप्टस अल्टीवेलिस*की प्लुरीपोटेंट ऊतक (आई पी एस) सेल लाइनों को उत्प्रेरित किया गया.

मछली पोषण में पोम्पानो के आहार में लिपिड आवश्यकता को 6-6.38% वर्णित किया गया. कोबिया को फ्यूकोडान, जो एक सल्फेटेड पोलिसैकेराईड होता है तथा भूरे रंग की शैवाल में पाया जाता है, को आहार के साथ देने पर उसमें प्रतिरक्षा में वृद्धि तथा जीवाणुरोधी लक्षण दिखाए दिए. *एम्फीप्रीयोन ओसीलेरिस* नामक समुद्री अलंकारी मछली में लाल मिर्च, हल्दी तथा पर्णरहित के द्वारा तैलीय राल का रंग तेज हो गया. इसी तरह पोर्टेरियाहोर्न्मानी नामक समुद्री शैवाल के आहार ने *एम्फीप्रीयान सनाडासिनोस* का रंग तेज कर दिया. पृथक शैवालों में दो नई प्रजातियों *विदुलफिया* एवं *कोलोस्तरेला* की पहचान की गई. सूक्ष्म शैवाल की वसा अम्ल संरचना का परिच्छेदन किया गया. गामाप्रोटियोबैक्टेरिम KX272637 से कोशिकाबाह्य लिपास का परिशोधन किया गया. सेफालोपोड के पोषण गुणों का परिच्छेदन किया गया. मेरु महाचिंगटो में वसीय पोषण आहार का मूल्यांकन किया गया एवं सूक्ष्म-बाध्य आहार विकसित किया गया.

मछली स्वास्थ्य प्रबंधन के क्षेत्र में खाद्य मछली एवं अलंकारी मछली में रोगाणु परिच्छेदन जारी रहा – मिजोस्पोरियांस की 2 नई प्रजातियों, *सेरातोमिजा कोलारी एन.एसपी.* एवं *सेरातोमिजा ल्युकोस्टेर्नोनी एन.एसपी.* के भारतीय समद्री अलंकारी मछलियों के रूप में घोषणा की गई. *स्केथोफेगस आर्गस* की आंत्र में एकान्थोसेफ्लान नामक परजीव की नई प्रजाति *फिलिसोमा केरालेंसिस* के संक्रमण की खोज एवं उसका वर्णन किया गया. पिंजरा फ़ार्म में जीवाण्विक संक्रमणका अध्ययन किया गया. *विब्रियो हारवेयी* एवं *फोटोबैक्टेरियम डैम्सेला एसएसपी. डैम्सेला* के दो प्रभेदों में दोहरे संक्रमण का अध्ययन किया गया *विब्रियो* को प्रोबायोटिक्स द्वारा नियंत्रित किया जा सकता है. कारवार के समुद्री बैस पिंजरा मछली पालन में स्नायु ऊतक्षकय विषाणु (एन एन वी) का निदान सी एम एफ आर आइ द्वारा विकसित "β -नोडाडिटेक्ट" नामक आरटी-लैम्प आधारित निदान किट द्वारा किया गया. स्पष्ट रूप से स्वस्थ हरित समुद्री सीपियों (*ऐरना विरिडिस)* के रक्त लासिका एवं उतकों (आहार नली, गिल, प्रावार एवं पेशी) में संवर्धन योग्य जीवाण्विक संग्रहण से सम्बंधित घनत्व एवं विभेद का अध्ययन किया गया. महाचिंगटों तथा भारतीय हैलिबट के लारवा तथा ब्रूड स्टॉक के स्वास्थ्य की निगरानी

जारी रखी गयी, चेनै में निषेचित मादा महाचिंगटों में झींगा भक्षी कृमियों के ग्रसन की निगरानी की गयी. राष्ट्रीय जलीय जीव रोग निगरानी कार्यक्रम के तहत लक्ष द्वीप एवं अँडमान सहित भारत के पूर्वी एवं पश्चिमी तटों पर जंगली एवं कृष्य द्विकपाटियों (मोलस्कन) में ओ आ इ वर्गीकृत रोगाणुओं की नियमित जांच की गई. मछली स्वास्थ्य सम्बंधी अखिल भारतीय नेटवर्क परियोजना के अंतर्गत प्रश्नावली आधारित सर्वेक्षण द्वारा जलीय संवर्धन में प्रयोग किये जा रहे उत्पादों के सम्बंध में सूचना एकत्रित की.

समुद्री जैव-औषधी के क्षेत्र में, समुद्री शैवाल से कडलमीन™ प्रतिअतिकोलेस्ट्रौल सत (एसीइ) नामक पौष्टिक औषधीय उत्पाद को विकसित किया गया. इस उत्पाद में बायोएक्टिव औषधीय गुणों वाले अपचायक हाइड्रोक्सीमैथिल ग्लुटैरिल कोएन्ज़ाइम, विभिन्न लक्षित संग्राहकों एवंमोटापा तथा डिस्लीपीडेमियादर घटाने वाले कारक अन्य एन्ज़ाइमों के संकेत मिले हैं. श्री जस्टिस पी. सदाशिवम माननीय राज्यपाल, केरल दिनांक 18 फरवरी 2017 को भा कृ अनु प- केन्द्रीय समुद्री मात्स्यिकी अनुसंधान संस्थान, कोच्ची में इस उत्पाद का विमोचन किया. समुद्री शैवाल के जीवाणु से एक सूक्ष्मजीवरोधी रोगोपचारी उत्पाद का विकास किया गया. मुख द्वारा औषधी ग्रहण एवं बाहरी अनुप्रयोग हेतु समुद्री शैवाल से प्राप्त एक प्रतिज्वलनशील औषधीयुक्त संपुटितसंकर औषधी वितरण व्यवस्था का मूल्यांकन किया गया. समुद्री शैवाल में पाए जाने वाले गामा प्रोटियोबैक्टेरियम की जीवाणुरोधी क्षमता का मूल्यांकन किया गया. भूरे रंग की समुद्री शैवाल से फ्युकोडाइन के जीवाणुरोधी तथा प्रतिरक्षा उद्दीपक गुणों को निकाला गया | विभिन्न समुद्री स्त्रोतों से जीवाण्विक विलगन के वाणिज्यिक रूप से महत्वपूर्ण एंजाइमों की उपस्थिति में जीवाणु पर जैवपूर्वेक्षण किया गया. समुद्री शैवाल *सरगासम माइरोसाइटम* में पाए जाने वाले समुद्री जीवाणु *बेसिलस सब्टिलिस* के प्रतिजीवाण्विक गुणों का अध्य्यन किया गया. एशियाई वनस्पति *रोज़ोफ़ोरा अन्नामलयाना* की लूप जड़ से दो दुर्लभ प्रतिआक्सीकारक तथा प्रतिज्वलनशील तैलीय उत्पादों की पहचान की गई| प्राकृतिक संकर वनस्पति*रोज़ोफ़ोरा अन्नामलयाना* से प्रतिआक्सीकारक एवं प्रतिज्वलनशील गुणों वाले जीवजनित ग्वाइनोलाइड किस्म के सेस्क्विटर्पीन लक्टोनों को पृथक एवं प्रदर्शित किया गया | खाध्य एवं औषधी उद्योग में प्रयोग होने वाले रिफाइंड मछली तेल की दुर्गन्ध रोकने में समुद्री शैवाल के कृत्रिम प्रतिआक्सीकरक के प्राकृतिक विकल्प के रूप में क्षमता को भी प्रदर्शित किया गया. *सर्गासिम व्हिटी* से प्राप्त *एरिल पोलिकेटाइड* औषधी के अपूर्व प्रतिआक्सीकारक एवं प्रतिज्वलनशील गुणों की खोज की गई. दीर्घशैवाल *एल्वारेज़ी कप्पाफायकस* एवं *ग्रेसीलेरिया ओपुंशिया* से सल्फेटेड पोलिगैलेक्टांस वाले प्रतिआक्सीकारक एवं अतितनावरोधी गुणों का मूल्यांकन विभिन्न परखनली तंत्रों के प्रयोग द्वारा किया गया.

समद्री अनुसंधान परियोजनाओं में, नारंगी रंग की ग्रूपर (*एपिनेफेलस* कोयिओइडस*)* एवं भारतीय पम्पानो (*ट्रकिनोटस मूकाली)* के पालन हेतु वितरित कुल बीज के 20% की अतिजीविता दर के साथ वृहद् स्तर पर उत्पादन प्रमुख उपलब्धि रही. *लेथरीनस लेंताजन नामक* ब्रीमका बीज उत्पादन भी महत्वपूर्ण खोज रही | समुद्री अलंकारी कूबड़ वाली चिंगट के अंडशावक का सफलतापूर्वक विकास एवं लारवा पालन तथा संकर पर्कुला क्लाउन मछली (पिकासो एवं प्लेटिनम) का वृहद् स्तर पर उत्पादन किया गया. कैलेनाइड कोपेपोडस की तीन महत्वपूर्ण प्रजातियों *अकार्शिया स्पिनिकोडा, तेमोरा टरबायीनाटा एवं स्यूडोडायप्टोमस सेरीकौडेटस* के बृहद् स्तर पर उत्पादन के संकेतों ने हमारी लारवा पोषण संबंधी प्रदर्शन को सुदृढ किया है. औसत बीज उत्पादन आंकड़े इस प्रकार हैं- कोबिया-1 लाख; पम्पानो- 2.5 लाख; (15 सेमी); ग्रूपर- 50,000; 14 अलंकारी मछलियों की श्रेणी में- 1.4 लाख, पर्ण शंबु- 10 लाख; होलोथूरिया स्कैब्रा- 50,000 एवं *पेनियस सेमिसल्केटस*- 5 लाख. सी एम एफ आर आइ की तकनीकी सहायता से सभी समुद्री राज्यों में से लगाए गए 1508 पिंजरों का प्रयोग स्वयं सहायता समूहों द्वारा वृहद् स्तर पर मछली पालन की तकनीकों को अपनाने का साक्ष्य है. इसके अतिरिक्त नीले स्विमर कर्कटों का परीक्षण उत्पादन 10% अतिजीविता के साथ प्रारम्भ किया गया. रामनाथपुरम जिले के वेदालाई ग्राम में मछुआरा समूहों के साथ सहभागिता आधार पर इन कर्कटों का परीक्षण संवर्धन प्रारम्भ किया गया है.

हमें शंबु संवर्धन में 90% तक की मृत्यु दर के कारण हानि हुई है. एक बहुशाखीय टीम ने इस संकट को वर्ष 2016 में खोजा एवं अक्तूबर 2016 में केरल सरकार को रिपोर्ट सौंपी. प्रमुख कारणों की खोज की गयी एवं 21 अनुशंषा की गयीं. इनमें फ़ार्म का पंजीकरण एवं लाइसेंस संबंधी कार्य मात्स्यिकी विभाग द्वारा स्थानीय पंचायतों के सहयोग से किया जाना है. फार्म इकाइयों की संख्या 20% तक घटा देनी है. इस रिपोर्ट को 15 अक्तूबर 2016 को भी लगभग 200 पालनकारों तथा एजेंटों के समक्ष प्रस्तुत किया गया. यद्यपि पालकार इन सिफारिशों पर सहमत थे.

केरल के 9 जिलों से लगते हुए भारतीय तटों के पारिस्थितिकी तंत्र में समुद्री जीवों के जैवसूचीकरण तथा जैवविविधता संबंधी आकलन विभिन्न कार्यप्रणालियों द्वारा किया गया | मात्स्यिकी, जलीय संवर्धन तथा कृषि जैसी अस्थायी व्यवसायों से कुल 1300440 रु./हैक्टे./प्र. व.(28899 डालर/हैक्टे./प्र. व.) की आय होती है. मन्नार की खाड़ी की जैवविविधता तथा कर्नाटक के तटीय पारिस्थितिकी तंत्र का मूल्यांकन किया गया. भारतीय समुद्र में प्रवाल भित्ति संरक्षण के प्रबंधन उपायों के गठन हेतु ग्रांड द्वीप, कच्छ की खाड़ी, गोवा, पाक की खाड़ी, टूटिकोरिन का प्रमुख बंदरगाह तथा लक्ष द्वीप के एन्द्रोथ, कल्पेनी एवं बितरा द्वीपों में जैव प्रवाल विविधता, मछली संयोजन एवं प्रवाल भित्ति से जुड़े अन्य जैव संसाधनों की जांच की गयी. मृदु प्रवाल के प्रजनन अध्ययन में *क्लादियेला लेसिनियोसा* नामक मृदु प्रवाल पर प्रयोगशाला परिस्थितियों में वृद्धि का अध्ययन किया गया. *सिनुलारियाक्वार्तिनेसिस* नामक मृदु प्रवाल पर कालिकट में प्रजनन अध्ययन किया गया.

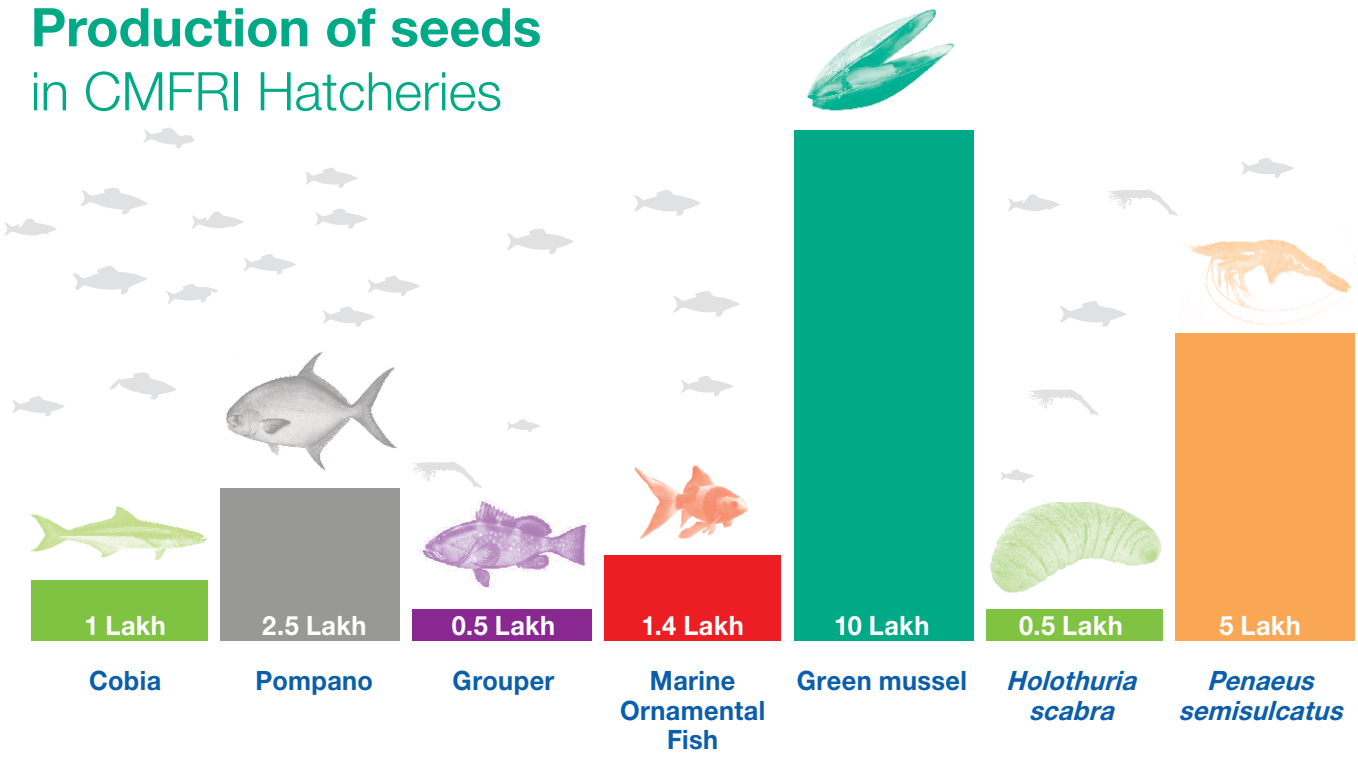
देवगढ़ द्वीप की जैवविविधता, जिसमें देवगढ़ द्वीप पारिस्थितिकी का मूल्यांकन शामिल था, का प्रवाल भित्ति द्वीप पारिस्थितिकी के मूल्यांकन में का अध्ययन किया गया. भारतीय तटों के शंख (शंखु घोंघे) के जातिवृत्त तथा आण्विक वर्गीकरण एवं स्ट्रोम्ब्स (मृदु कवची जठरपाद) का अध्ययन बाह्य वित्तपोषी परियोजना के अंतर्गत किया गया.

समुद्री वास विषयगत क्षेत्र में केरल में तालुकवार मात्स्यिकी क्षेत्र में समुद्री कूड़े एवं मत्स्यन संभार एवं समुद्री तटों पर कूड़े की मात्रा की जांच की गयी | मैंग्रोव एवं समुद्री घास जैसे महत्वपूर्ण स्थानों पर कूड़े का प्रभाव तथा मछली की आंत्र में दीर्घ प्लास्टिक की उपस्थिति और समुद्री तेल के प्रदूषण का सामान्य रूप में अध्ययन किया गया. करापाड की खाड़ी एवं टूटिकोरिन में उड़ती हुयी राख के निक्षेप का अध्ययन तथा अनुपचारित म्युनिसिपल मॉल का प्रभाव भी इस अध्ययन के पहलुओं में से थे. इस परियोजना में महत्वपूर्ण समुद्री आवासों की पारिस्थितिकी प्रकिया पर तथा प्रोटोकॉल का प्रत्यवस्थापन हेतु विकास, केरल के कीचड़ वाले समुद्री किनारों पर जैविक-पर्यावरणीय प्रक्रियाओं, पश्चिमी तटों पर पर ब्लूम्स *नोक्तिलुका एसएसपी.* का अध्ययन एवं प्रलेखन किया गया. उत्तर मानसून काल में अजैव कारकों तथा फाइटो प्लैंक्तोन की भी सघन जांच की गयी. समुद्री घास की पारिस्थितिकी, मंग्रोव प्रत्यवस्थापन, नेत्रावती मुहाने की साईट की पहरे द्वारा निगरानी एवं तटीय एवं समुद्री पक्षियों की निगरानी भी इस अध्ययन का भाग था. तारली के वासों में पारिस्थितिक विभिन्नताएं एवं केरल में इनके प्रभाव पर अध्ययन एक महत्वपूर्ण कार्य है जिसने जनता का ध्यान आकृष्ट किया है. भारतीय तटों से समुद्री शैवाल का संसाधन मूल्यांकन, दोहन एवं उपयोग अन्य अनुसंधान परियोजना है जिसके द्वारा समुद्री संसाधनों के बारे में सूचना दी जाती है. भारतीय समुद्र में स्तनधारियों के संरक्षण की क्षमता में प्रभावी रूप से वृद्धि का अध्ययन कार्य भी प्रमुख रूप से केन्द्रित है.

सी एम एफ आर आइ ने कोचीन शिपयार्ड के सहयोग से पारिस्थितिकी तंत्र को समुद्री कूड़े से भारी चेतावनी के बारे में लोगों में जागरूकता लाने के उद्देश्य से फोर्ट कोची के दक्षिणी तट पर 2500 वर्ग फीट क्षेत्र में एक 13 फीट ऊंची "फिश सीमेट्री" नामक स्थापना कला का विकास किया है. इस कृति का सृजन कोचीन शिपयार्ड के वित्त पोषण से श्री मनोज ब्रम्हमंगलम एवं श्री प्रमोद गोपालकृष्णन ने श्री एन्टणी फेलिक्स, श्री अजी कुमार एवं श्री संजय रंजन कार्तिक के साथ मिलकर किया है.

जलवायु परिवर्तन एवं इसका समुद्री मात्स्यिकी पर प्रभाव भारतीय कृषि अनुसंधान परिषद के पश्चापसारी जलवायु कृषि पर राष्ट्रीय नवोन्मेष (निक्रा) कार्यक्रम के अंतर्गत आते हैं. प्रग्रहण मात्स्यिकी में सुभेद्यता मूल्यांकन, मैंग्रोव में कार्बन स्टॉक मूल्यांकन, जलवायु प्रतिरूप एवं वितरण में परिवर्तन तथा जोनेथिडस की समुदाय संरचना, अंडजनन अध्ययन, फाइटोप्लैंकटोन समुदाय में एसएसटी एवं तारली की प्रचुरता एवं जीवन चक्र मूल्यांकन के सम्बन्ध में परिवर्तन का अध्ययन किया गया. समुद्री संवर्धन में, समुद्री शैवालों की कार्बन प्रथक्कीकरण क्षमता, समुद्री संवर्धन के लिए जलवायु

Production of seeds in CMFRI Hatcheries



प्रत्यास्थता प्रजातियों की पहचान, पिंजरा पालन में तकनीक प्रदर्शन एवं एकीकृत बहु पौष्टिक मत्स्य पालन आदि गतिविधियाँ, प्रशिक्षणकार्यक्रम एवं प्रौद्योगिकी स्थानान्तरण संबंधी पहल की गयी. खतरे में पड़े तटीय मत्स्य समुदायों की सुभेद्यता मूल्यांकन- अंत में जलवायु परिवर्तन के हानिकारक प्रभावों से निपटने के लिए एकीकृत जिला स्तरीय अनुकूलन एवं शमन ढांचा का गठन किया गया.

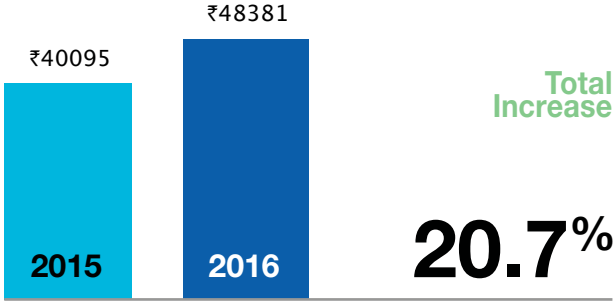
समुद्री मत्स्य अवतरण में, आर्थिक प्रदर्शन एवं आपूर्ति श्रृंखला प्रबंधन, वर्ष 2016 में अवतरण केंद्र स्तर पर समुद्री मत्स्य अवतरण का अनुमानित मूल्य 48,381 करोड़ (2015 की तुलना में 20.69% वृद्धि) रहा एवं खुदरा स्तर पर 73,289 करोड़ (2015 की तुलना में 12.44% वृद्धि) प्राप्त हुए. अवतरण केंद्र पर मछली की बिक्री 133.38 रुपये प्रति किलोग्राम (2015 की तुलना में 13.18% वृद्धि) पर की गयी एवं खुदरा बाज़ार में 201.89 रुपये/कि.ग्रा. (2015 की तुलना में 5.46% वृद्धि) पर हुई.

प्रजातियों की मात्रावार भागीदारी एवं विक्रय (प्रतिशत में), मूल्य श्रंखला में राज्यवार मूल्यांकन, समुद्री मत्स्य अवतरण का राज्यवार मूल्यांकन, समुद्री मात्स्यिकी क्षेत्र में माल के कुल मूल्यांकन का प्रलेखन भी किया गया. भारत में समुद्री मात्स्यिकी क्षेत्र के दीर्घ संकेतक, मत्स्यन प्रणालियों का आर्थिक प्रदर्शन, केरल में मछलियों की आवक, घरेलू मत्स्य व्यापार पर विमुद्रीकरण का असर एवं उपभोग को भी दर्ज किया गया. स्थानीय समाधानों हेतु वैश्विक ज्ञान एवं अधिगम: समुद्र निर्भर तटीय समुदायों की सुभेधता को कम करना-सामाजिक आर्थिक सुभेद्यता का मूल्यांकन एवं तटीय समुदाय सुभेद्यता के मूल्यांकन हेतु वैचारिक ढांचे का विकास भी किया गया.

मत्स्य नियंत्रण में, जीविका जनन एवं कल्याण अनुसंधान, क्षमता विकास उपायों के प्रभाव का मूल्यांकन किया गया. मत्स्यन निषेध मौसम में जीविका पर असर तथा इसका केरल के संसाधन उपयोग पर प्रभाव का अध्ययन मिशिगन

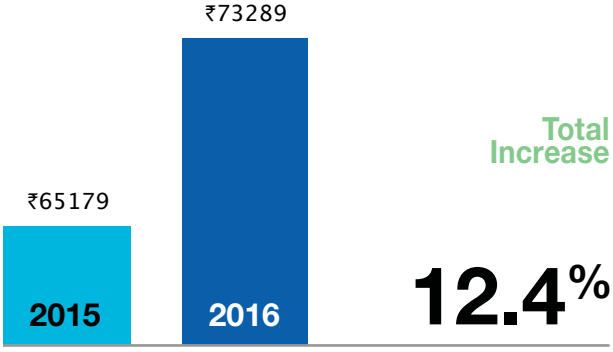
State-wise landing centre value
in ₹crores and % variation with 2015

Kerala	₹ 9149	-4.4%
Gujarat	₹ 8427	19.9%
Tamil Nadu	₹ 6492	15.2%
Karnataka	₹ 6247	35.3%
Odisha	₹ 1645	-33.7%
Maharashtra	₹ 5369	16.1%
Andhra Pradesh	₹ 2516	-17.5%
West Bengal	₹ 5501	350.9%
Goa	₹ 997	-5.9%
Daman & Diu	₹ 1433	131.1%
Puducherry	₹ 605	218.4%



State-wise retail centre value
in ₹crores and % variation with 2015

Kerala	₹ 12398	-15.3%
Gujarat	₹ 13130	12.2%
Tamil Nadu	₹ 10728	11.2%
Karnataka	₹ 9108	18.4%
Odisha	₹ 2836	-29.5%
Maharashtra	₹ 8313	10.9%
Andhra Pradesh	₹ 3916	-18.9%
West Bengal	₹ 8190	425%
Goa	₹ 1451	-32.5%
Daman & Diu	₹ 2351	120.4%
Puducherry	₹ 868	128.4%



विश्वविद्यालय, अमेरिका के वित्त पोषण से किया गया. समुद्री मत्स्यन क्षेत्र में जनन मुख्यधारा में केरल मे *थीरामैत्री* पहल का कार्य-निष्पादन मूल्यांकन भविष्य की दूरदर्शिता के लिए निगरानी मूल्यांकन लाभ के उद्देश्य से किया गया. समूह के सदस्यों में सामंजस्य का विश्लेषण कर सफल समूहों को श्रेय दिया गया. सी एम एफ आर आइ ने लेनदेन में पारदर्शिता हेतु टाइम्स रजिस्टर (निगरानी एवं मूल्यांकन तंत्र पर *थीरामैत्री* सूचना) के नाम से एक लेखा बही विकसित की है. 35 शिक्षित बेरोजगार युवा मछुआरिनों के लिए महिला मछुआरिनों की सहायता हेतु समिति (एस ए एफ) के वित्त पोषण से दो माह के क्षमता निर्माण प्रशिक्षण कार्यक्रम का आयोजन थीरानाय्पुण्या-II में युवा मछुआरों में कौशल विकास एवं क्षमता निर्माण के उद्देश्य से किया गया. भारत में मात्स्यिकी बीमा का स्तर हमारे मूल्यांकन में एक नया क्षेत्र था. कृषि प्रौद्योगिकी सूचना केंद्र (ए टी आइ सी) जो कृषि विज्ञान केंद्र के बिक्री केंद्र के साथ कार्य करते हैं, के द्वारा 346286 रुपये का राजस्व अर्जित किया गया.

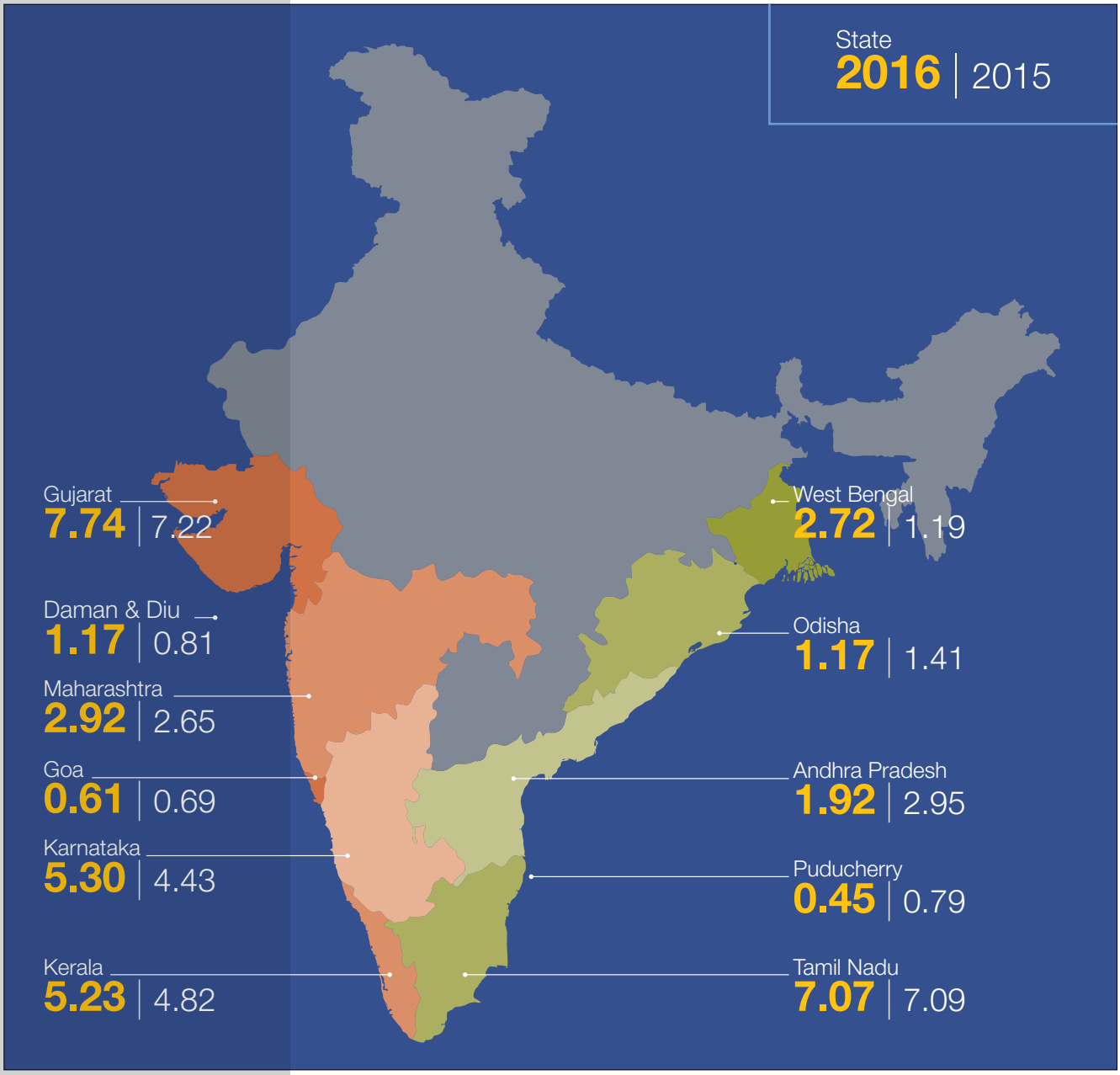
इस वर्ष सी एम एफ आर आइ को भा कृ अनु प द्वारा सातवीं बार 'ग' क्षेत्र में वर्ष 2014-15 के दौरान के श्रेष्ठ राजभाषा कार्य-निष्पादन हेतु राजर्षि टंडन पुरस्कार से सम्मानित किया गया. हमारा संस्थान भा कृ अनु प दक्षिण जोन खेलकूद प्रतियोगिता 2016 में समग्र विजेता रहा (दूसरी बार). मछुआरों के लिए संस्थान की एम@कृषि सेवा ने विदेश मंत्रालय एवं नीति आयोग द्वारा प्रदत्त सामजिक नवोन्मेष पुरस्कार 2016, देश के 20 सर्वश्रेष्ठ समुद्री नवोन्मेष की श्रेणी में जीता.

ईप्रिंट्स@सी एम एफ आर आइ, संस्थानिक खुली पहुँच कोष (रिपोसिटरी) भा कृ अनु प संस्थानों में शीर्ष पर, भारत में तीसरा, एशिया में 41वें एवं विश्व में 324 वें स्थान पर रहा.

केरल के माननीय राज्यपाल जस्टिस पी. सदाशिवम ने सी एम एफ आर आइ के वर्ष भर चलने वाले प्लेटिनम जयन्ती समारोह का उद्घाटन दिनांक 18 फरवरी 2017 को किया जिसमें हमारी योजना 70 गतिविधियाँ आयोजित करने की है जो संस्थान की आयु की ओर तथा देश की सेवा में सात दशकों की अथक सेवा को इंगित करती हैं |

Major Achievements

- Captive breeding and seed production of Indian pompano (*Tachinotus mookalee*), pig face bream (*Lethrinus lentjan*) and orange spotted grouper (*Epinephelus coioides*)
- Notification of National Policy on Marine Fisheries (NPMF) with inputs from the fisheries management plan (FMP) projects and the policy cell of CMFRI
- Indian Marine Fisheries Code drafted by CMFRI leading to the establishment of a marine fisheries management model for India
- Whole mitogenome of the edible oyster *Crassostrea madrasensis* was characterised
- Geographical Information System (GIS) based inventorying of the marine fish landing centers in the country
- Release and commercialisation of Cadalmin™ Anithypercholesterolemic extract from seaweeds for dyslipidemia and obesity
- 'mKrishi' mobile application developed for use by fishers mentioned by the Prime Minister of India in his 'man ki baat' programme for its applicability in reduction of scouting time and increase in fuel efficiency
- Received Rajarshi Tandon Award for the 7th time for excellent Official Language implementation
- Completes 70 years of service to the nation and celebrates its Platinum Jubilee



Fishery resource monitoring

Fish harvests

Research Project: FISHCMFRISIL201200100001

In the year 2016, marine fish production of the country has shown an increase of 6.6% compared to 2015 recording a total of 3.63 million t. Indian mackerel became the highest contributor with 2.49 lakh t as the declining trend in Indian oilsardine landings continued. Hilsa shad, the favourite fish in West Bengal recovered from the dwindling landings in the

Estimated Marine Fish Landings (t) in India 2016

Pelagic finfish	
Clupeoids	
Wolf herring	17657
Oilsardine	244992
Other sardines	195163
Hilsa shad	93679
Other shads	12565
Anchovies	
Coilia	30618
Setipinna	6990
Stolephorus	61571
Thryssa	42255
Other clupeoids	58579
Bombayduck	144951
Half beaks & full beaks	5593
Flying fishes	3427
Ribbon fishes	217100
Carangids	
Horse mackerel	39936
Scads	105057
Leather jackets	17428
Other carangids	83566
Mackerels	
Indian mackerel	249241
Other mackerels	401
Seerfishes	
Scomberomorus commerson	37677
Scomberomorus guttatus	17110
Acanthocybium spp.	224
Tunnies	
Euthynnus affinis	35466
Auxis spp.	13418
Katsuwonus pelamis	16232
Thunnus tonggol	8090
Thunnus albacares	16792
Other tunnies	1637
Bill fishes	16815
Barracudas	37817
Mullets	7964
Unicorn cod	108
Others	
Seaweeds	20576#
Total	**3734882**

Demersal finfish	
Elasmobranchs	
Sharks	23002
Skates	3627
Rays	26211
Eels	11171
Catfishes	80559
Lizard fishes	94817
Perches	
Rock cods	42781
Snappers	10533
Pig-face breams	12519
Threadfin breams	170349
Bull's eyes	130740
Other perches	40321
Goatfishes	30276
Threadfins	9728
Croakers	157793
Silverbellies	92764
Whitefish	6312
Pomfrets	
Black pomfret	13924
Silver pomfret	26012
Chinese pomfret	4227
Flat fishes	
Halibut	2713
Flounders	100
Soles	41015
Crustaceans	
Penaeid prawns	200116
Non-penaeid prawns	169558
Lobsters	2976
Crabs	56679
Stomatopods	13861
Molluscs	
Mussels, oysters and clams	84483#
Other bivalves	1216
Gastropods	2759
Cephalopods	
Squids	114886
Cuttlefish	101805
Octopus	14585
Miscellaneous	79769

#The estimates are based on an alternate method and are excluded from the comparisons made. The comparisons are based on 3629823 t (3734882-20576-84483=3629823)

previous years, to reach high landings up to 0.94 lakh t. Another species which emerged as a major resource is bull's eye (*Priacanthus* spp.) which registered record landings of 1.30 lakh t, mostly from the west coast.

A state-wise analysis of the estimates indicates that the maritime states of West Bengal, Kerala, Karnataka, Maharashtra, Gujarat and the U.T. of Daman & Diu registered increase in landings whereas the other coastal states Odisha, Andhra Pradesh, Tamil Nadu, Puducherry and Goa recorded a decline. Gujarat retained the top position among the states with 7.74 lakh t landings followed by Tamil Nadu which landed 7.07 lakh t. For the first time Karnataka attained the third position pushing down Kerala into 4th position with 5.30 and 5.23 lakh t respectively. The state of West Bengal recorded maximum percentage increase (129%) in landings with 2.72 lakh t compared to 1.19 lakh t in 2015. All the other states in the east coast and the U.T. of Puducherry had decreased landings compared to last year. The six coastal states along the west - Kerala, Karnataka, Goa, Maharashtra, Gujarat and U.T. of Daman & Diu recorded increase in landings among which Karnataka registered a maximum of 19.6% increase.

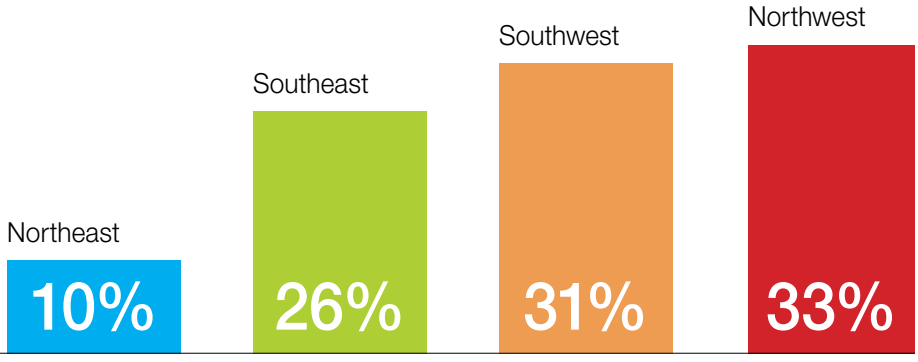
Region-wise catch contribution

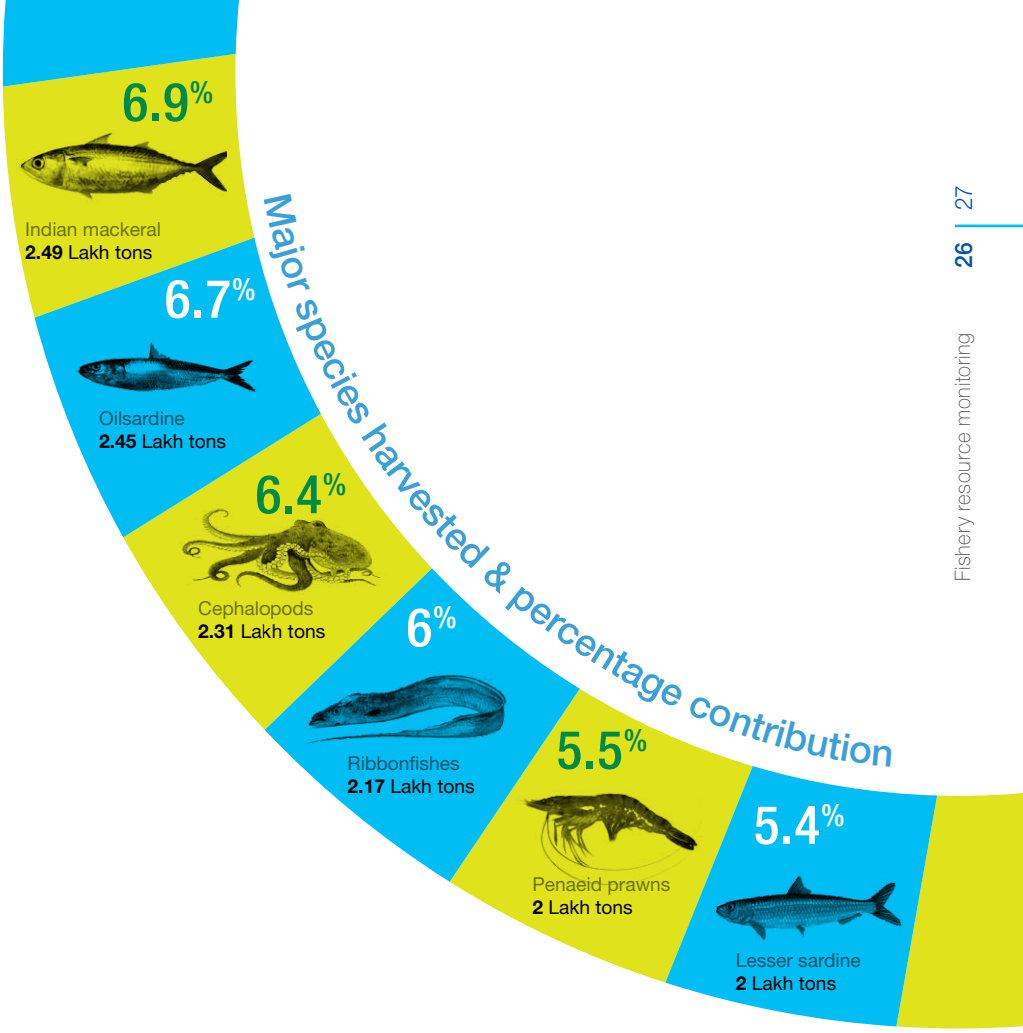
Among the four regions of the Indian peninsular coast line, the north-west coast comprising of Maharashtra, Gujarat and Daman & Diu contributed maximum share with 33% of the total landings (11.83 lakh t). The next major contribution was from the south-west region where Kerala, Karnataka and Goa together produced 11.13 lakh t which accounted for 31% of the total landings in the country. In spite of a continuing decline in oilsardine landings, Kerala attained 8% increase in the total landings in 2016 with an upsurge in the landings of other resources such as scads and bull's eye.

Southeast region states Tamil Nadu, Puducherry and Andhra Pradesh registered a total production of 9.44 lakh t which accounted for 26% of the all India marine fish landings. The maximum contribution was from Tamil Nadu which recorded 7.07 lakh t with a slight decrease of about 2000 t from the previous year. The state of Andhra Pradesh recorded a massive decline (35%) of about 1 lakh t in 2016 registering the total catch of 1.92 lakh t. This drop in landings is due to the cyclonic weather condition that prevailed in the last few months of the year.

The states of West Bengal and Odisha which forms the northeast coast contributed 3.89 lakh t forming 11% of the all India landings. Total landings of West Bengal increased with a remarkable hike to reach 2.72 lakh t from the 1.19 lakh t obtained in 2015. Almost all the main resources in the state have shown the increasing trend but the major contribution was that of Hilsa shad, the most favourite fish in the state. The estimated landings for Hilsa shad have touched a new record of 89,109 t from 16,273 t of previous year. In contrast, the state of Odisha recorded a decrease of 16.7% registering a total catch of 1.17 lakh t. The loss of fishing days due to cyclone warnings affected the fishery of the state as in the case of Andhra Pradesh.

Region-wise contribution



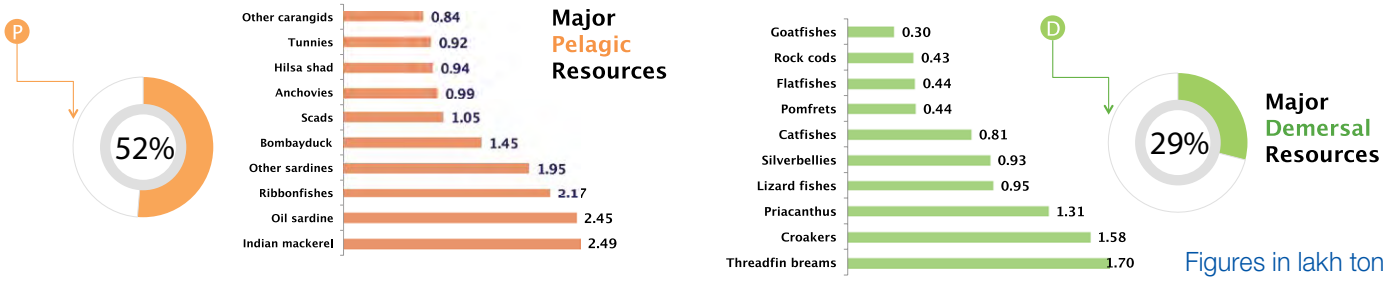


Major species harvested

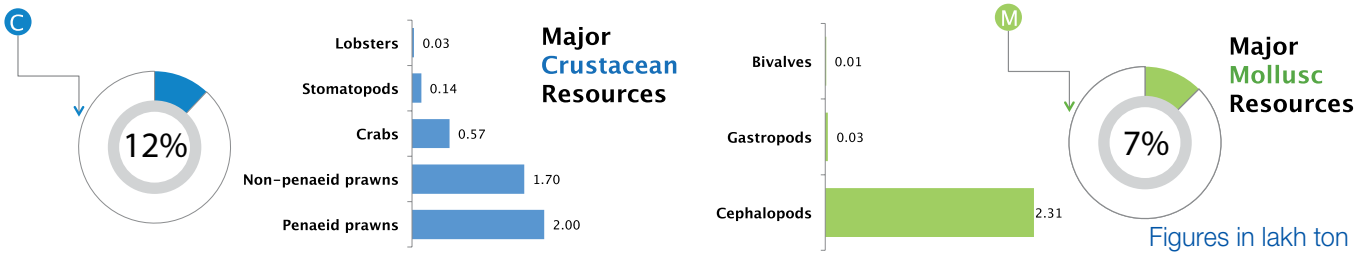
Indian mackerel occupied the first position among the major resources landed all over the country, with an overall production of 2.49 lakh t ahead of oilsardine (2.45 lakh t). For the first time since 1998, oilsardine was not the top ranked species in terms of catch as it fell below Indian mackerel. Since 2012, oilsardine landings continued to show a decreasing trend, with an estimate of only 2.45 lakh t. A significant change observed in 2016 is in the landing pattern of bull's eyes (*Priacanthus* spp). From a mere 4,691 t in 2015 its landings has been escalated to a six times high of 1.30 lakh t in 2016.

Resource-wise contribution

Pelagic resources contributed 52% of the total landings of the country with major share of Indian mackerel, oilsardine and ribbonfish. Demersal finfish formed 29% in which threadfin breams, croakers and *Priacanthus* spp. were found as the major groups. The share of crustacean resources in the landings was assessed at 12% of the total landings and that of molluscan resources at only 7% where squids and cuttlefishes got the maximum share.



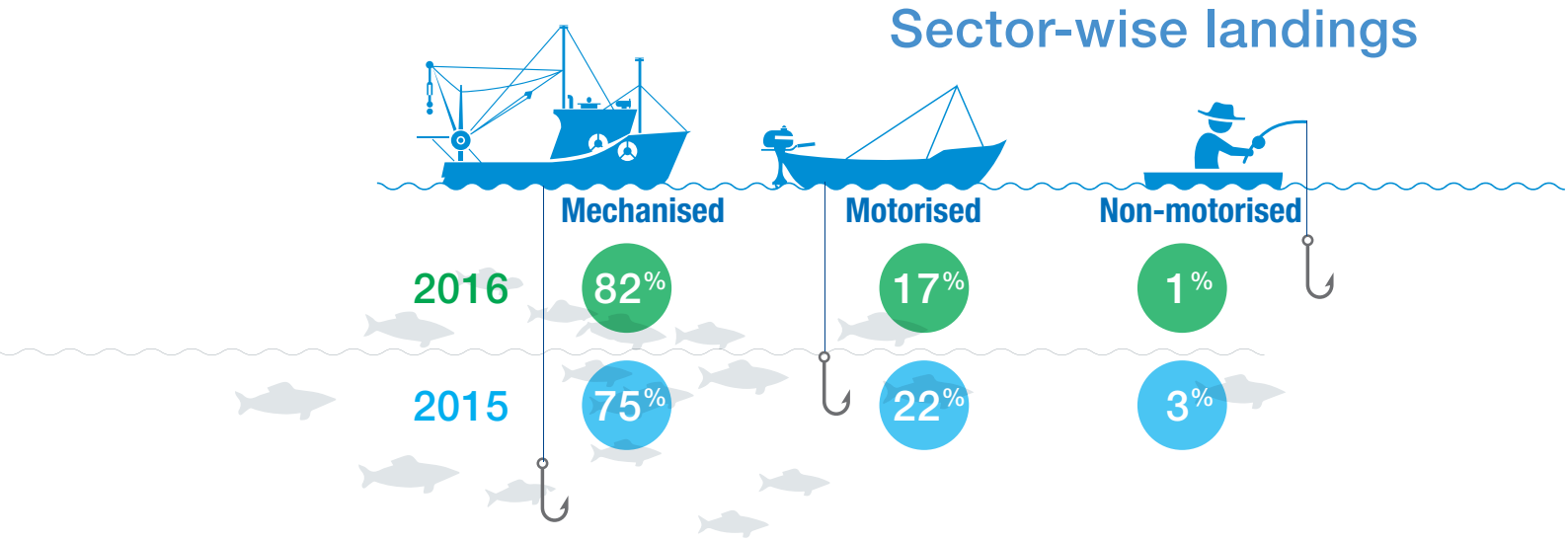
Figures in lakh ton



Composition in landings under diffferent assemblage groups

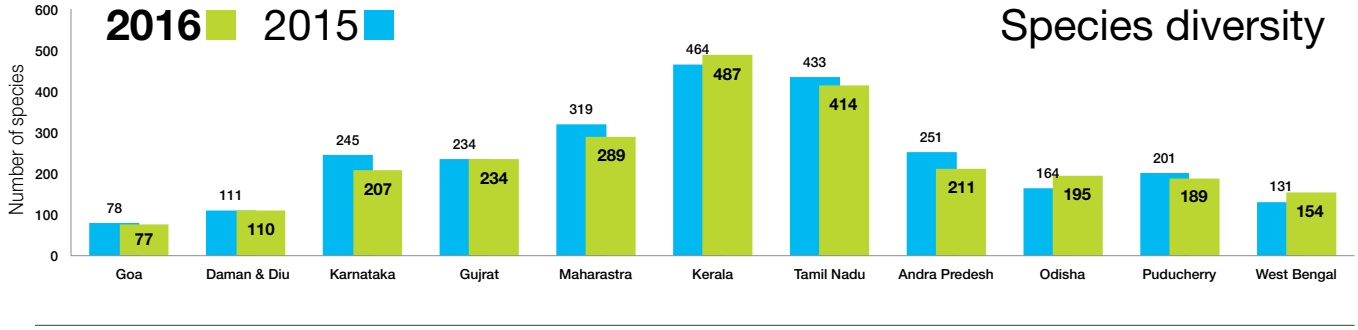
Fishing sector contribution

Among the three different categories of crafts used for fishing, the contribution from mechanised sector was 82% and that from motorised sector was 17%. The contribution from the non-mechanised sector was only 1%. In this categorisation, mechanised sector includes crafts which use upwardly powerful engines which are deployed for propulsion and fishing in tandem with propulsion. The highest contribution was from trawlers, which was around 57% in 2016. In both 2015 and 2016, the catch per hour of multiday trawlers were more or less the same. The motorised sector was replete with use of gillnets, seine nets, hooks & lines and bagnets.



Species diversity

The total number of species found in the landings along the Indian coast during 2016 was 709 where as it was 730 in 2015. Kerala is at the top with landings of 487 species followed by Tamil Nadu with 414 species. The least number of species landed was in Goa. Though Gujarat had maximum landings among all the maritime states alpha diversity was less compared to Kerala and Tamil Nadu.



National Marine Fisheries Census - 2016

Household level information about social and other aspects of marine fishermen population collected during the Marine Fisheries Census 2016, from 4057 villages were digitised utilising the ASRB online examination facility at CMFRI Hqs by hiring 70 data entry personals. Software for enabling the data entry into a database was developed in-house. Information pertaining to 8,82,263 marine fisherfolk households collected were digitised and stored in MS Access database. Information on fishing crafts and fishing gears in the fishery were collected using Schedule-III from all the 1281 marine fish landing centers and fishing harbours in the country.

Software development

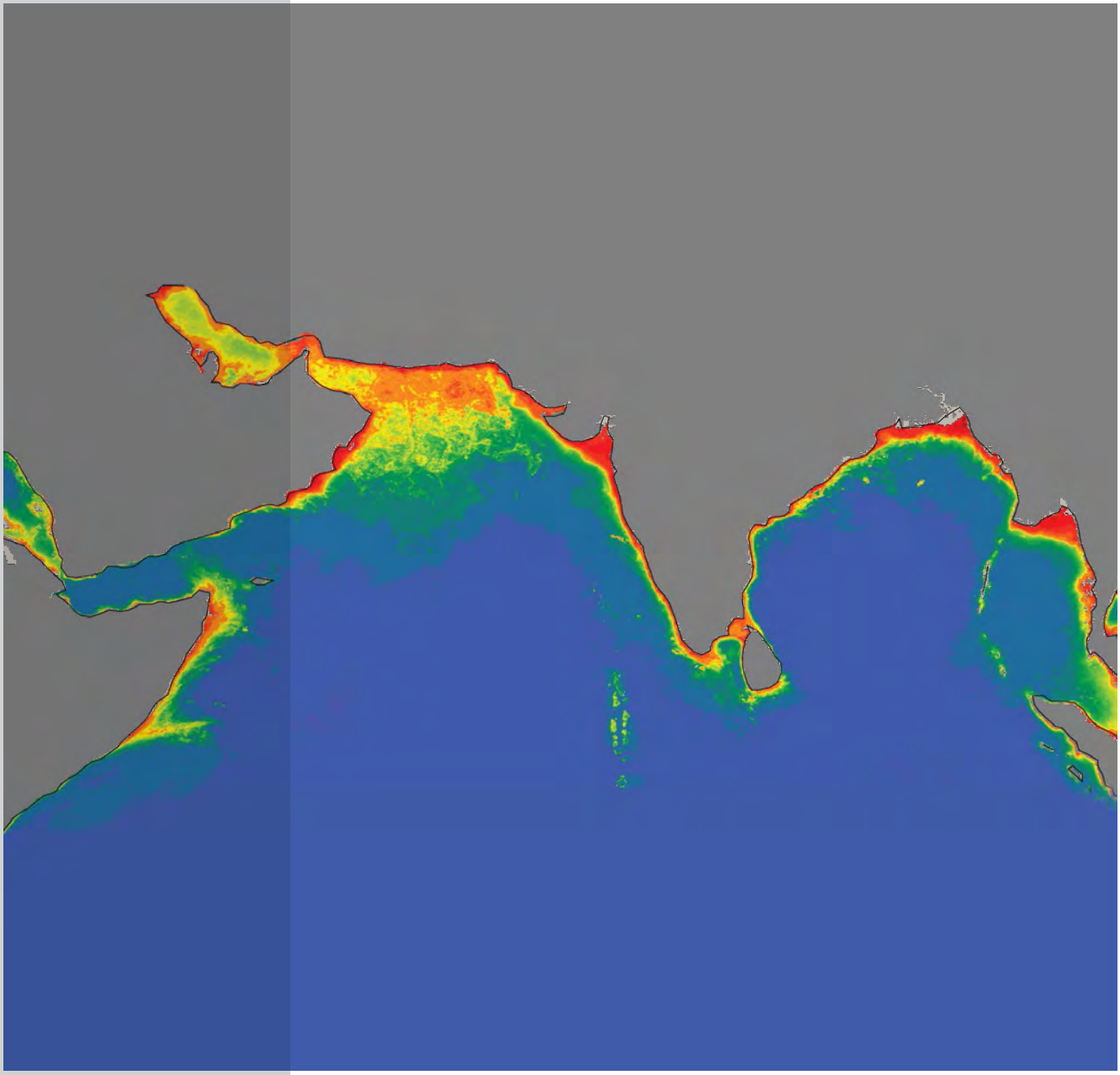
The web based computer application for online data entry of marine fish landings data using electronic tablets at landings centres was completed, tested and is ready for use. The web based application developed has facilities for (i) Online data entry using electronic tablets from landing centres, (ii) Utilities for scrutiny of data at headquarters, (iii) Data analysis for estimation of marine fish landings and standard error of estimates and (iv) Generation of reports of estimated figures in various formats.

Web application for equality test of male/female LW relations

Developed a web application for test of equality of regression lines which is mostly applied in fisheries to compare length-weight (LW) relationships between males and females as well as between fish stocks. The application is hosted in the intranet for easy access by the end users.

Web application for estimation of biological reference points

Developed a web based application for estimation of maximum sustainable yield (MSY), Biomass at MSY level (BMSY) and Fishing mortality at MSY level (FMSY) using length frequency data based on Thompson and Bell yield prediction model. The web application was hosted in the Institute intranet and is made available for fishery management projects. The length frequency data is uploaded in standard 'csv' format and other inputs are read directly from input boxes. The software finally produces the plot and yield predictions for different levels of exploitation levels. Final result is exported into excel format for further use.



Fisheries and ecosystem modeling

Multi-species stock assessment

Research Project: FISHCMFRISIL201200100001

Estimation of stock status, maximum sustainable yield and optimum fishing effort for three resources namely oilsardine, Indian mackerel and *Stolephorus* for the fishery in Kerala were carried out using multi-species stock assessment model, a multivariate version of Schaefer's model wherein the current biomass is expressed as a function of previous year biomass and catch. Time series data

on landings and fishing effort during 1995-2015 for the three resources were used as input for the model. Simultaneous estimation of all the parameters of the model, namely carrying capacity, intrinsic growth rate, catchability coefficient, maximum sustainable yield, biomass level corresponding to the maximum sustainable yield and optimum fishing effort were carried out by adopting Bayesian estimation through Markov Chain Monte Carlo procedure, an iterative procedure based on Gibbs sampling using OpenBUGS software. As per the attempted multispecies model, the maximum sustainable yield for the three resources in Kerala are 2.42, 1.10 and 0.45 lakh t respectively.

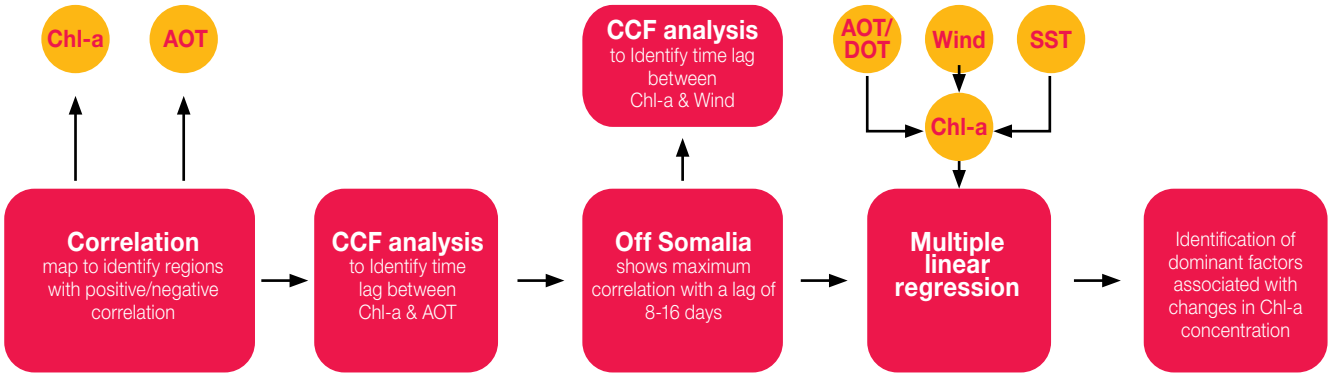
Stock assessment for large pelagics

Estimated maximum sustainable yield for seerfish for the northeast region using time series data on catch and fishing effort (hours of operation) through modeling using SEAMICE model. Automatic differentiation model builder was used to arrive at the estimates and the final estimate of maximum sustainable yield for seerfish fishery in northeast region is 32,645 t.

Relationship between chlorophyll concentration and marine aerosols

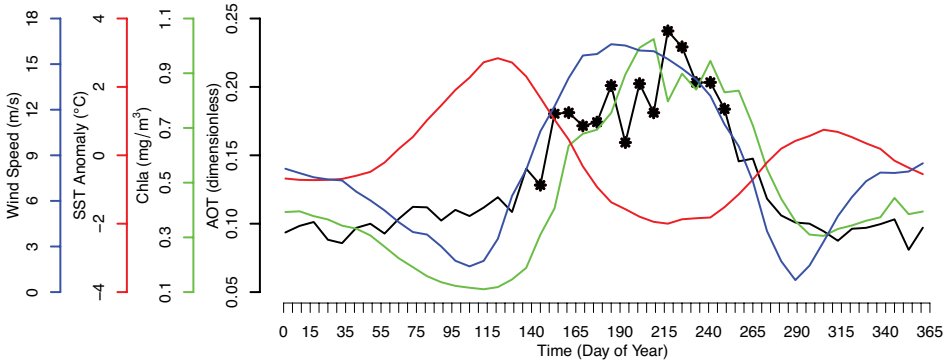
Research Project: FISHCMFRISIL 201200200002

Correlation between Aerosol Optical Thickness (AOT) at 865 nm and Chlorophyll-a (Chl-a) concentration for the period 1998-2013 over the Northern Indian Ocean was studied using the 8-day composites. The results showed areas of both positive and negative correlation. Some locations, including both coastal and open-ocean regions, showing either positive or negative correlations, were selected for further study.



Flow chart for methodology adopted for the study

The Cross Correlation Function (CCF) analysis for the selected regions with positive and negative correlation between AOT and Chl-a concentration showed that the maximum CCF values occurs with a lag. Further analysis were made for the 20 X 20 box off Somalia where the highest significant positive correlation between AOT and Chl-a occurred when AOT leads Chl-a by 8-16 days. For further understanding of the relationship between AOT and Chl-a, 8 day climatological anomalies for AOT, Chl-a and Sea Surface Temperature (SST) and wind speed were calculated, and results are shown for the study region- off Somalia. The climatological time series of both AOT and Chl-a show presence of dust aerosols (shown as asterisks) when AOT and Chl-a reaches its maximum during summer monsoon season. For the region off Somalia, SST and wind speed varies seasonally with increasing temperature until the end of March and starts decreasing from April till the end of SW monsoon (June- September) due to upwelling. A second peak in SST is also seen just before the start of NE monsoon (October-November). During the peak in SST, Chl-a concentrations are at its lowest. Though SST starts decreasing due the advent of upwelling, the effect on Chl-a is only seen after approximately 3 weeks. This lag may be due to dilution of Chl-a during the initial phase of upwelling, due to mixing associated with upwelling.

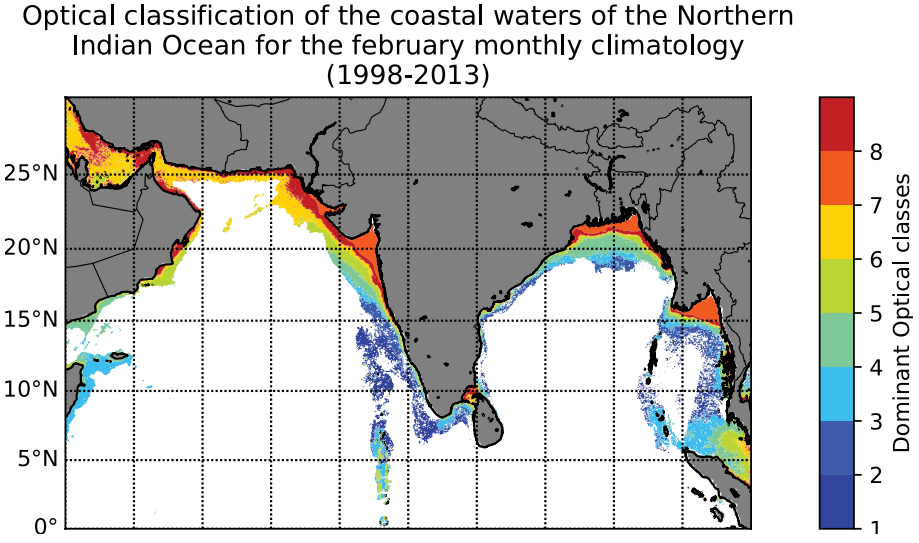


Climatological time series for wind speed, SST, Chl-a and AOT

Since the northwestern Arabian Sea, including the region off Somalia Coast, is one of the areas with the highest dust load in the Indian Ocean, the micro-nutrients in the aerosols could be a source of phytoplankton enhancement in this location. But, when all three variables were considered together in a multiple linear regression, the increase in r^2 associated with the AOT is only about 0.02, a consequence of covariance among SST, AOT and alongshore wind speed. The results for the western Arabian Sea off Somalia indicate only a possible minor role for dust aerosols enhancing Chl-a concentration during the summer monsoon, supplementing the major role of alongshore winds inducing upwelling favourable for phytoplankton growth.

Optical classification of coastal waters

Monthly climatological dataset of remote sensing reflectance for the years 1998-2013 was obtained from the Ocean Colour Climate Change Initiative for the Northern Indian Ocean. Normalisation and log-transformation of remote sensing reflectance values were done based on standard scientific methods. Optical classification was implemented using fuzzy logic method. Optimal cluster validity methods such as Xie-Beni Index and Partition Coefficient were computed to determine the optimal cluster (class) number to perform the classification. To aid the selection of optimal class number, the maps of cumulative membership of all the class numbers from 5 to 15 were also studied. The cluster number 8 gave the best compromise, with low numbers of both under-classified and over-classified pixels. Therefore, eight classes were selected as the optimal cluster number for classification. Similarly, the monthly variations of optical classes of all the months were plotted and studied in detail.



The mean spectra of the eight selected optical classes were calculated. The optical classes also relates to Case-1 and Case-2 waters as defined by earlier researchers based on spectral shapes. From the shapes of the spectra, it appears that classes 1-6 are representative of Case-1 waters and classes 6-8 of turbid Case-2 waters. Optical diversity of the study region was also assessed by calculating the Shannon index. The diversity index calculation was performed for the normalised memberships for all months to show the seasonal variations in optical diversity. Diversity index (H) for the coastal waters of the northern Indian Ocean fell mostly between 0.001 and 1.4. Further, the resultant optical classes were analysed to explore their biological significance using the available distribution datasets of different taxonomic groups of phytoplankton and zooplankton from literature and COPEPOD database.

Ecosystem modeling for higher trophic level community

In order to assess the impacts of overfishing upon food chain, a pilot study was employed using OSMOSE (Object-oriented Simulator of Marine ecoSystems Exploitation) model configured for the Kerala coast with prime focus upon two species namely *Trichiurus lepturus* and *Sardinella longiceps*. Study revealed the delicate inter-dependence of different species and yielded insight into the abrupt changes reflected at the ecosystem level owing to overfishing. Assessment of the impacts of overfishing upon ecosystem served as a valuable tool in formulating decisions and framing policies that aim at encouraging sustainable harvest of these resources. The study took a closer look at the effects of overfishing upon the population dynamics of higher trophic level species along the Kerala coast using OSMOSE model (a multi-species individual-based model which assumes size-based opportunistic predation). The spatial domain of the study extended from 6°N to 14°N and 73°E to 77°E covering the entire Kerala coast. The forage species is represented by *Sardinella longiceps* whereas *Trichiurus lepturus* formed predatory species. In order to understand the effects of overexploitation of fishery resources, the fishing mortality of the chosen species was kept at initial values for the normal scenario, whereas it was increased up to ten times its initial value so as to simulate the overfishing scenarios for a duration of 12 years. Depletion of planktivorous species due to excessive fishing did not have a significant impact upon the biomass of the predatory species since the predators were able to thrive upon zooplankton in the absence of forage species whereas exhaustion of predatory species due to overfishing contributed to a steeper increasing trend in biomass of planktivorous species that had no predators to keep its population under check.

Development of data management system

For handling and summarising the *in situ* data along with providing a platform for centralised collection of *in situ* data for multiple access from different centres, a database management system was developed. It benefits in the storage and archival of the data with an ease of access by the users to a single repository as if 'Access to the *in situ* data anywhere, any time and for anyone'. The referred *in situ* data contains parameters related to water, plankton, sediment, benthos and fish catch data which were collected by different research centres of CMFRI over years. A user manual highlighting the steps involved in data upload and management (filtering) has also been prepared. It gives further insights to the end user with respect to the required formats of the files accepted for uploading multiple variables associated with *in situ* data along with their respective units and relevant screenshots depicting data filtering process along with the estimation of basic statistical properties associated with variable of interest.

Fish distribution response to oceanographic forcing

The relationship of oceanographic forcing (physical and chemical) upon fish response (spatial distribution) has remained largely elusive owing to the lack of synoptic-level datasets on the oceanographic variables. The study helps to establish the qualitative link between synoptic scale oceanographic forcing and fish response (distribution) along the eastern coast of Arabian Sea. The study site was demarcated with respect to 15°N latitude, as NEAS (Northeast Arabian Sea) located north of 15°N latitude and SEAS (Southeast Arabian Sea) located south of 150N latitude.

The breeding season for carnivores occurs during winter in tropics which coincides with the high chlorophyll biomass observed in the coastal waters of northeast Arabian Sea during November to February due to influx of aerosol from Indian sub-continental desert regions and winter cooling. The spawning activity of pelagic planktivorous fishes, which peaks during summer monsoon coincides with upwelling along the southeast coastal waters of Arabian Sea during May to September. Catch ratios derived from fish landing estimates highlight the increased abundance of carnivorous fish species characterising denser coastal waters along the northeast Arabian Sea whereas the lighter coastal waters along the southeast Arabian Sea are dominated by planktivorous counterparts within the exclusive economic zone of India. The denser surface coastal waters of northeast Arabian Sea ensure that the eggs remain suspended within the euphotic zone with better food availability and less predators, which in turn leads to minimal larval loss to the unfavourable conditions at greater depths. Moreover, the equatorward and poleward ocean surface currents during summer and winter monsoon along the eastern Arabian Sea results in the horizontal movement, dispersal and resulting aggregation of planktonic pelagic fish larvae towards their feeding grounds characterised by the presence of increased chlorophyll biomass which in turn improves its chances of survival and eventual recruitment to the fish stock.

GIS based resources mapping of distribution and abundance

Research Project: FISHCMFRISIL201200900009

The monthly operational details of different gears from different maritime states was recognised as a very handy tool in ensuring safety of fishermen at sea and also marine spatial planning of future development in coastal waters. Areas of heavy incidence of juvenile bycatch were identified in Gujarat, Maharashtra, Karnataka, Kerala and Andhra Pradesh. Spatio-temporal maps were made to understand the seasons of heavy incidence of juveniles from these states. In Maharashtra, the seasons of high incidence of juveniles of commercial species in dolnets were identified. Juvenile exploitation of pomfrets and ribbonfishes was found to be very high in certain months.

Protocol development for resource mapping and fishing operation area mapping

Spatio-temporal mapping of fishery resources and fishing operations were carried out using specially designed protocols. Important gears operated and the species exploited from the coast were identified for data collection. Seasonal and spatial changes of species composition and juvenile & spawner composition of selected species was the major focus of the mapping. The protocol elucidated the application of GIS in the marine fisheries sector in India, describing the protocols for mapping marine fishery resources caught using all the gears operated along Indian coast, using GIS platform.

Resource mapping and mapping of fishing operational area

A total of 1,502 GIS maps were prepared from the data received from 10 operating centres and were analysed to derive the fishery related information. Out of which, 480 maps were drawn on fishing gears *i.e.*, gillnet, trawl net, dolnet, shore seine, ring seine, purse seine, chinese dipnet, hook and line and thalluvalai; and 1,022 maps were drawn on different resources such as croakers, perches, gastropods, shrimps, lobsters, crabs, deep sea prawns, tunas, seerfishes, mackerel, crabs, threadfin breams, whitefish, ribbonfishes, stomatopods, etc.

Mapping of trawling ground

Mapping of commercial trawling grounds along Indian coast was prepared to know about the extent of trawling activities along Indian coast and the fishing activities from different states with reference to their territorial water. This is the first record depicting the extend of trawling operation from different maritime states showing the complexity of fishing operational areas,

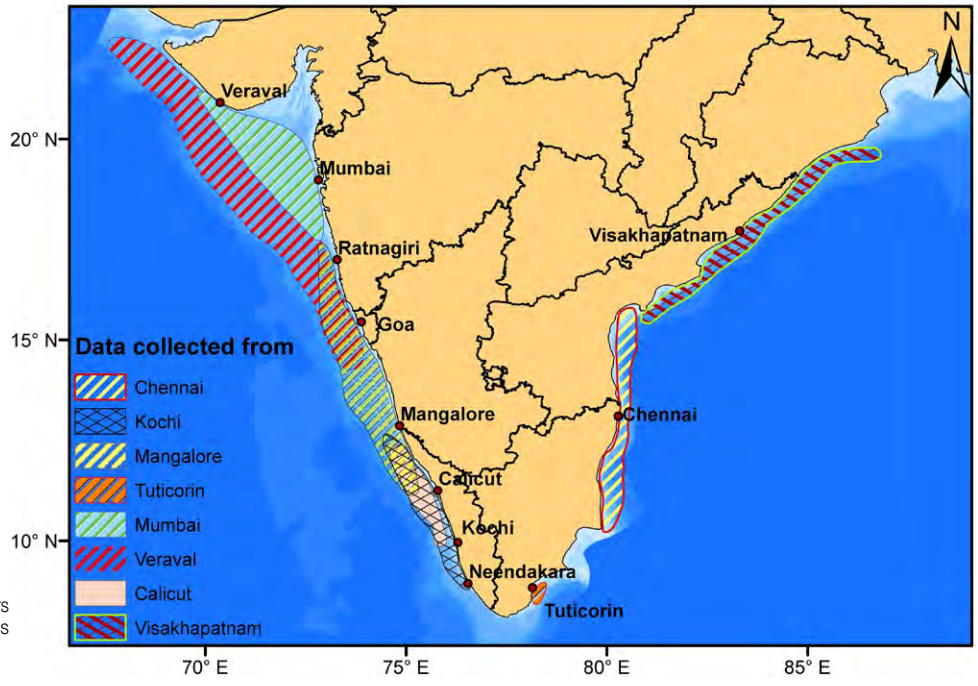
which necessitates spatial data based policy development and implementation for effective management of fishing operation and resource management.

Resource mapping

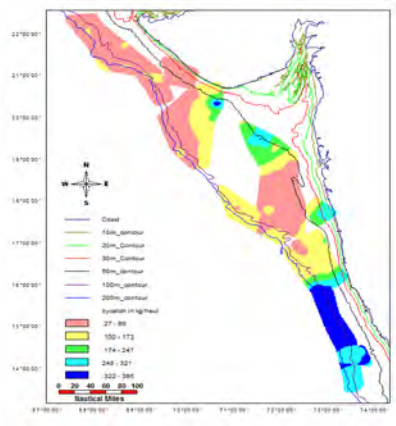
The resource maps were proved as an excellent tool for the policy makers to weigh each fishing ground in terms of commercial value and juvenile abundance so that the policy making process will be much transparent. Vulnerable fishing grounds in terms of high bycatch incidence were mapped in Gujarat. Seasonal maps were also made to identify the seasons of high incidence of juveniles of different species. Seasonal migration patterns of tunas were mapped to know the movement of tunas according to the seasonal variation of temperature.

Apart from the mapping of fishing grounds and resources in trawl fisheries of Maharashtra, most significant results came out of mapping the "Dolnet" fishery. Area of operation of dolnetters were identified and mapped in GIS format with the help of GPS coordinates collected along with catch data. Month-wise maps of species composition and juvenile composition of fishery resources were prepared.

Most extensive spatio-temporal analysis of fishery data was carried out along Karnataka-Goa coast. GIS based resource mapping of juvenile and spawner abundance along Karnataka coast was attempted for deriving criteria for spatial and temporal closure or restriction in trawl fishery. Seasonal peak spawning grounds were identified for *N. randalli, M. monoceros, S. tumbuil* and *T. lepturus* based on the GIS studies. Peak spawning months and area of occurrence also could be derived from the map. Similarly, seasonal juvenile abundance grounds identified for *N. randalli, N. japonicus, L. lactarius* and *E. diacanthus*. Months of juvenile abundance and area of occurrence also could be derived from the maps. Fishing area of emerging resources such as 'bull's eye' was mapped to understand its spatial distribution pattern. Globally trawl footprint studies are being used to identify the vulnerable marine ecosystems (VME) which will help to focus the fishing impact studies based on the critical nature of the fishing ground. With geo-spatial database, trawling footprint analyses were carried out at Mangalore, which is the first time attempt of trawl foot print studies in Indian waters. Trawl footprint studies revealed that more and more areas which were considered not suitable for bottom trawling are being



Mapping of trawling grounds operated by trawlers from fishing centres of different maritime states

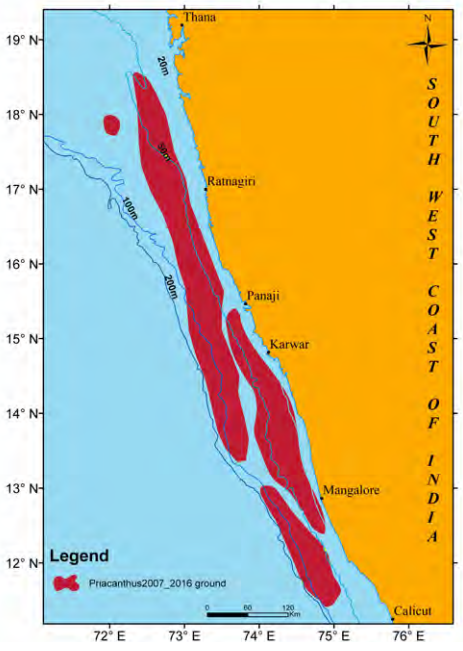


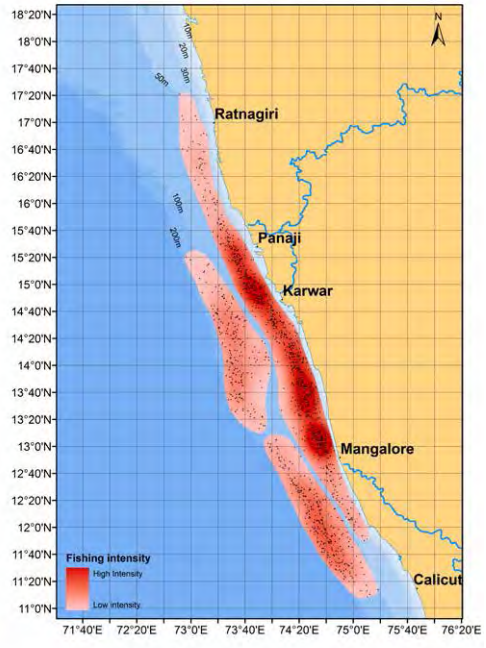
Areas of heavy incidence of juvenile bycatch observed in the trawlers operated from Veraval

exploited during last few years by trawlers operating high speed pelagic/ off-bottom trawls.

Seasons of high incidence of bycatch and juveniles were identified by resource mapping from Calicut, Kochi and Shakthikulangara fishing harbours. Resource mapping of demersal fishes, shrimps, crabs and gastropods were carried out over space and time. In Kerala the seasonal variations in catch from traditional gillnet off Chellanam and Munambam areas were mapped to understand the juvenile and spawner abundance and also to understand the period during which heavy destruction of juvenile fishes are taking place. Period of high incidence of juveniles in Chinese dipnets also were identified. In Vizhinjam, resource mapping and analysis of shore seines catch were carried out to understand the juvenile and spawner abundance of commercial fishes in shore seines.

Mapping of hook and line fishery was done from Chennai Research Centre. From Tuticorin, resource mapping of drift and single day trawlers were carried out. Vulnerable fishing grounds in terms of high bycatch incidence were mapped in Andhra Pradesh. Seasonal maps were also made to identify the seasons of high incidence of juveniles of different species.





Distribution map of 'bull's eye' resources prepared from catch records of trawlers operated from Mangalore during 2007-13.

Map showing the extent of trawl operations from Mangalore during 2013-16, illustrating that the areas unsuitable for bottom trawling are being brought under exploitation by new trawling methods.

Variation in areas which occur as PFZ 2003-2007 *vs* 2013 to 2016

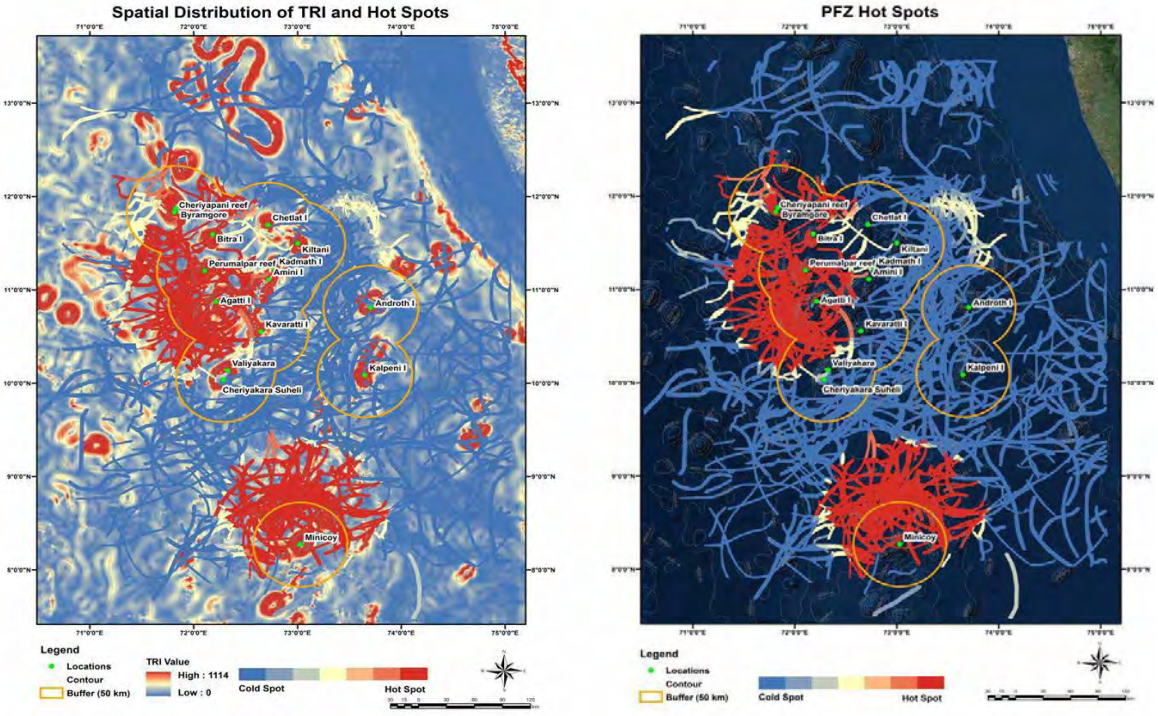
Research Project: EFP-9

An analysis conducted during 2011 on the PFZ advisories for Kerala coast indicated that the nearshore areas, with depth less than 50 m frequently occur as PFZ (51%) compared to areas along the continental slope and continental shelf. However, from 2013 to 2016, it was observed that the near shore region did not occur as frequently as it used to and the persistence was reduced to 32%. Similarly the inshore areas of northern and central Kerala used to occur more frequently as PFZ areas. These variations are reflected in the sardine fishery also. The variation in PFZ occurrence was reflected in the catch also.

GIS mapping of tuna advisories

In the Lakshadweep group of islands, 19 locations have formed PFZ for tunas as per the INCOIS advisories. The most frequently occurring area as PFZ among these was Minicoy (9.6%), followed by Suheli (8.6%), Cheriyakara (8.4%) and Kalpeni (8.1%). The PFZ advisories were plotted on GIS platform and using the digital elevation model, the Terrain Ruggedness Index was also plotted.

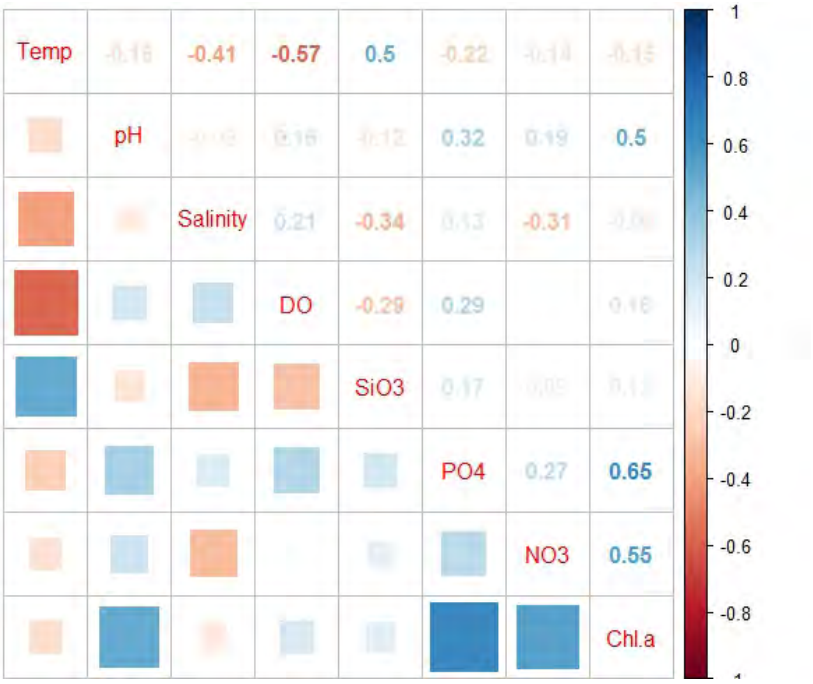
More than 130 observations on catch and price were made and validation comparisons were carried out. It was observed that only during August (87% more) and October (31% more), the catch was more in PFZ areas than non PFZ areas. The profit was nearly 90% more in August, but in October the profit was at par with non PFZ areas. During November to February, the catch was higher in the non PFZ area, which were tested (Agathi, Minicoy and Androth). In Minicoy, at the same location even when there was no advisory, the catch was very high.



Modeling bio-geochemical cycles in coastal oceans

Research Project: EFP-29

Analysis of physical, chemical and optical parameters were done onboard and collection of samples for the estimation of nutrients, chlorophyll, CDOM, PI and productivity parameters were done off Veraval coast up to 50-60 m depths. Physico-chemical parameters such as temperature, pH, salinity and dissolved oxygen were measured during sampling. Nutrients *viz.* silicates, phosphates and nitrates were measured along with gross primary productivity, net primary productivity and chlorophyll-a. Correlation studies of physical, chemical and nutrient parameters revealed positive correlation between nutrients and chlorophyll-a, than the physical and chemical parameters on chlorophyll-a.



Correlation among physical, chemical and biological parameters

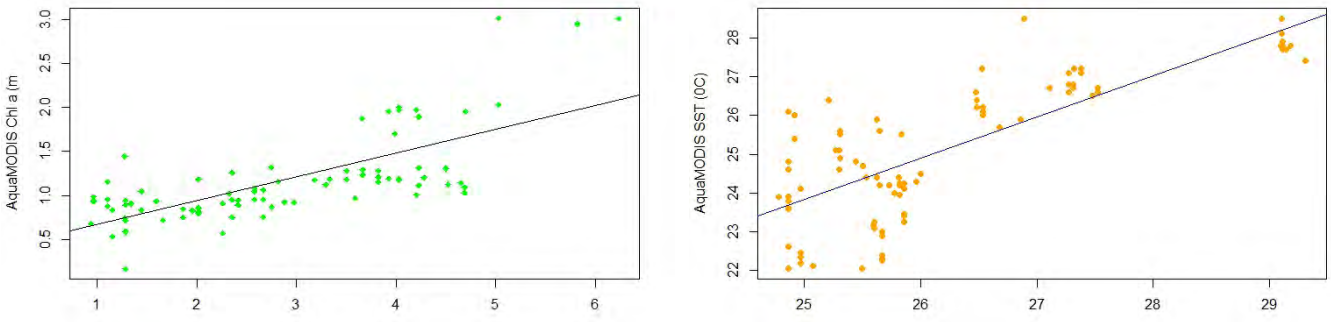
Generalised additive models

Generalised Additive Model (GAM) was used to develop a prediction algorithm with nutrients (silicates, phosphates and nitrates) as independent parameters and chlorophyll-a as the predictor. Nutrients such as phosphates and nitrates showed significant impact ($p<0.001$) on chlorophyll-a and no significant impact by silicates. The three nutrients together explained 56.8% of deviance of chlorophyll-a.

Evaluation of satellite data with *in situ* data

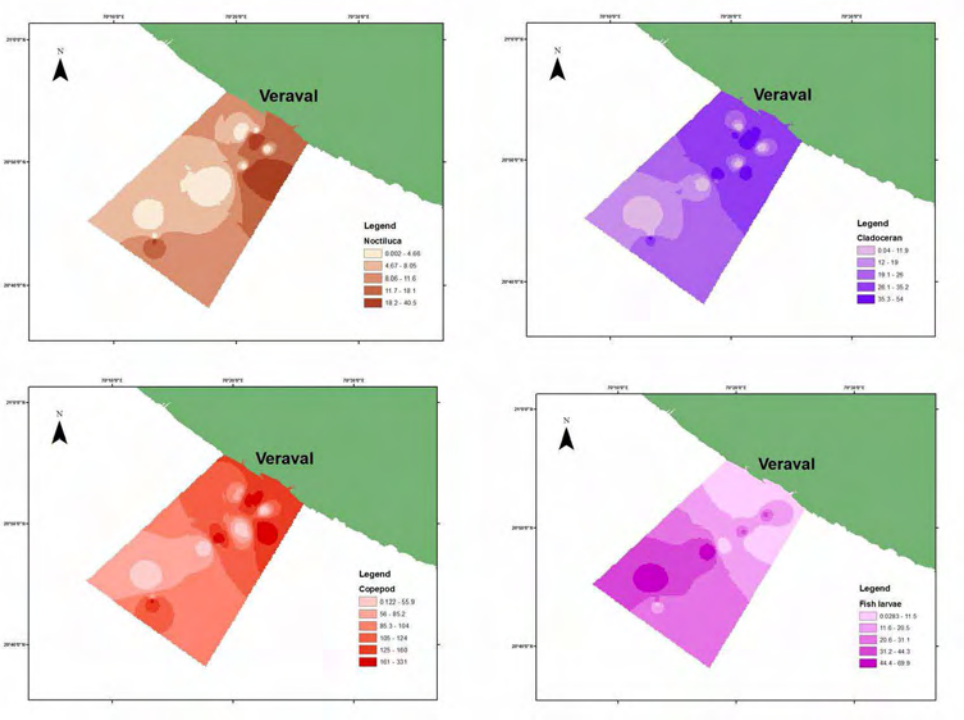
A study was conducted to validate the satellite ocean color data sets parameters, *i.e.* sea surface temperature (SST) and chlorophyll-a (Chl-a) in relation to *in situ* data off Veraval coast of Gujarat. The validation studies used a set of *in situ* SST and Chl-a measurement, collected from 90 sampling locations (N=90) to evaluate the Aqua MODIS (4 km). A highly significant relationship was observed in SST ($R2 = 0.63$, $p<0.001$) than the Chl-a ($R2 = 0.51$, $p<0.001$). The study reveals the overestimation in satellite derived Chl-a than the *in situ* data. The algorithms need to be further developed with more sampling points on a regional level.

Validation of satellite ocean color data set parameters with *in situ* measurements



Plankton samples analysis and mapping

Plankton samples were collected and analysed on a spatial and temporal basis. Geo-spatial maps for the important plankton species/groups were plotted along the sampling locations. Pigment analysis of the Phytoplankton Functional Types (PFTs) using HPLC was initiated in collaboration with ISRO-Space Applications Centre, Ahmedabad. Optical parameters such as euphotic depth, remote sensing reflectance, phytoplankton absorption and CDOM absorption were observed onboard using radiometer. Phytoplankton absorption showed low values during pre-summer months (March-May) indicating low productivity. Chlorophyll-a was also found to be lower during pre-summer months during the study period. CDOM absorption showed low values during pre-monsoon months and high values during the post and winter monsoon months



Geo-spatial maps of major plankton groups, *i.e. Noctiluca*, Cladocera, Copepods and Fish larvae

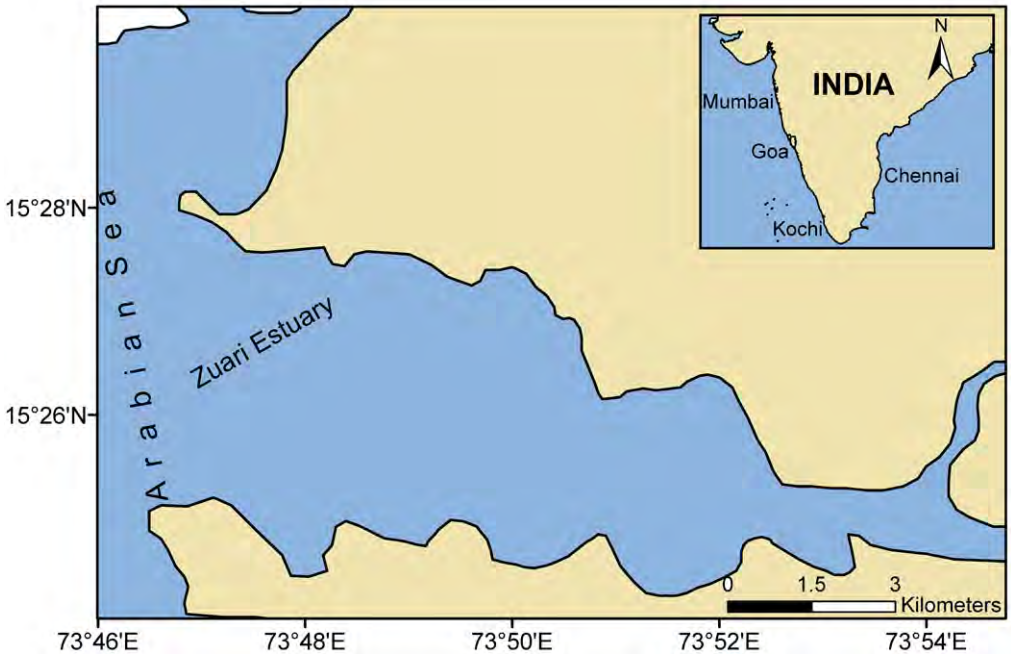
Flow of matter through trophic levels and biogeochemical cycles in marine and estuarine ecosystem

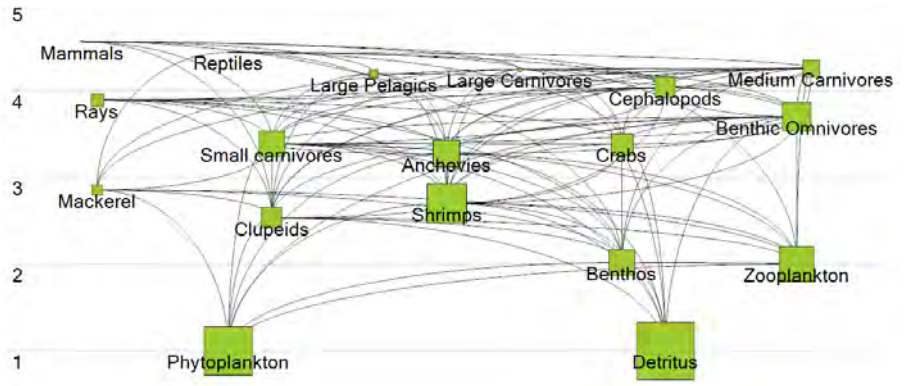
Research Project: EFP - 2

Preliminary mass balancing of the trophic model for Zuari estuarine ecosystem was carried out during the period. The mass balanced model is aimed to construct quantitative description of trophic structure and relationship among different groups in the whole of Zuari Estuary of Goa. The model is based on the data inputs during 2012-15 and is the first ecopath model for Zuari Estuary. The model present a preliminary revelation of the trophic structure and flow in the estuary between the function groups.

Ecological or functional grouping were made taking into consideration that within groups, the species have similar sizes, similar population characters, similar food and similar predators. On the basis of this criteria, the resources in Zuari were grouped into 18 ecological groups for modeling. The ecological grouping covered more than 80% of the resources in the commercial catch from the ecosystem. The input parameters (biomass, P/B and Q/B ratios, diet matrix and fishery information) for the model were calculated and entered into the basic input sheets.

The 18 ecological groups include 111 exploited fish and commercial invertebrate species as well as the energy (feeding) fluxes. The parameterisation of the model reflects the ecological and multispecies interactions and the total system throughput estimated for Zuari Estuary is 4611 t km^{-2} yr^{-1} which is comparable to other estuarine ecosystems. The ecosystem had an estimated mean trophic level of 3.2 with the minimum of 1 for phytoplankton and maximum of 4.2 for marine mammals. The total primary production/total respiration ratio of 1.94 implies that the ecosystem is in developing stage with its ratio greater than 1. The net system production value of 873 t km^{-2} yr^{-1} obtained for Zuari estuarine ecosystem indicates the developing nature of the ecosystems. The total system biomass that is supported by the available energy flow in a system can be expected to increase to a maximum for the maturest stage of a system. The system biomass / throughput ratio is 0.009 for Zuari estuarine ecosystem. System omnivory index (OI) of 0.425 was obtained, indicating consumer feeding on different trophic levels. The flow to detritus was maximum for benthos followed by zooplankton. The least flows were observed for apex predators. The maximum primary production required for harvest of groups was observed for small carnivores. The maximum primary production required for consumption of groups was observed for Cephalopods. The high model estimate of total system throughput of 9229 t km^{-2} yr^{-1} may be due to high biomass and production values of producers and nutrient loading in the coast. The primary production/respiration ratio (PP/R) is 1.94 which implies that the ecosystem is in the developing stage and are prone to ecological changes, including anthropogenic impacts.





Flow diagram of trophic interaction for the Zuari estuarine ecosystem of Goa

Vulnerability assessment of marine fishery resources in South Kerala to climate change

Research Project: EFP-12

Vulnerability assessment of different species in the fishery in south Kerala was carried out separately for each fishing zone. The vulnerability matrix was prepared by giving more weightage to climatic variables as the sensitivity traits are dependent on changes in the climatic variables. Vulnerability matrix for different fishing zones was generated by plotting impact versus vulnerability score. Climate exposure ranking of pelagic resources was higher than that of demersal resources. The index of exposure and sensitivity attributes was classified into high, medium and low for the 68 species assessed for vulnerability. The climatic variability score was medium in southwest zone. Thirty percent each of the species studied were found medium vulnerable to climate change. Black pomfret (*Parastromateus niger*) was assessed as highly vulnerable in the region.

Modeling oil sardine, mackerel and ribbonfish fishery in South Kerala

Time series data on landings of oil sardine, Indian mackerel and ribbonfish along with fishing effort (hours of operation) during the period 1991-2014 for the South Kerala region was used for attempting SEAMICE model (Socio-Ecological Adaptations Model of Intermediate Complexity for Ecosystems) with sea surface temperature (SST) during the same period as auxiliary variable. The freeware ADMB (Automatic Differentiated Model Builder) was used to estimate the parameters of the model such as carrying capacity, intrinsic growth rate, biomass, mortality, catchability coefficient and finally the maximum sustainable yield.

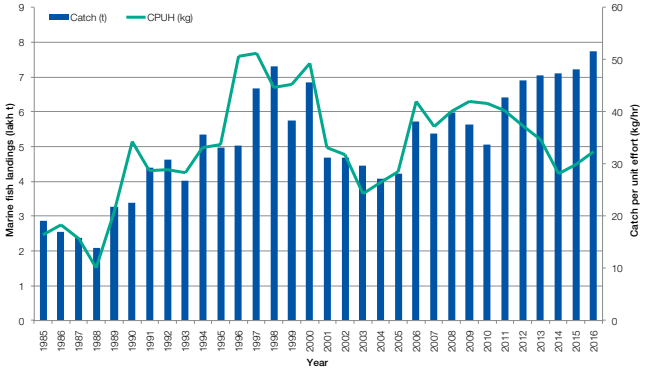
Sustainable management of fishery resoruces

Gujarat

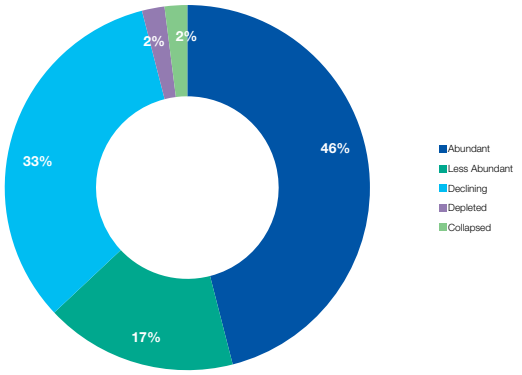
Research Project: FISHCMFRISIL201200400004

Gujarat registered an all-time high of 7,74,373 t of marine fish landings during 2016, Gir-Somnath District being the highest contributor (3,42,224 t). The annual fish landings showed increasing trend compared to previous year (7.23 lakh t). Historic marine fish catch registered an increasing trend in Gujarat, but catch per hour (CPH) showed a declining trend during recent years.

District-wise, Gir-Somnath ranked first with 3.42 lakh t followed by Porbandar (1.13 lakh t), Amreli (0.91 lakh t), Dev Bhoomi Dwaraka (0.85 lakh t), Junagadh (0.72 lakh t), Kutch (0.35 lakh t), Valsad (0.25 lakh t), Navsari (7506 t), Jamnagar (2999 t), Morbi (261 t) and Baruch (181 t). Pelagic finfish resources contributed 38%, followed by demersals 32%, crustaceans 22% and



Catch and catch rates (kg h^{-1}) of marine fish landings of Gujarat



Rapid stock assessment of fish species groups - 2016

molluscs (8%). Sector-wise catch from mechanised fishing vessels dominated with 7.09 lakh t followed by motorised vessels 0.65 lakh t and non-motorised vessels contributing meagerly 166 t. MDTN contributed 53% of the annual fish landings, followed by other gears like MDOL (32.24%), OBGN (7.80%), MGN (3.44%), MTN (2.71%) and others (0.81%). Catch per unit effort (CPUE) was highest in MDTN 3.90 t, followed by MDOL 1.77 t, MTN 0.57 t, MGN 0.30 t and OBGN 0.15 t. Highest CPH (kg h^{-1}) was observed in MDOL (93 kg), followed by MTN (47 kg), MDTN (40 kg), MGN (9 kg) and OBGN (9 kg).

Rapid stock assessment

Rapid stock assessment (RSA) was done for the 52 commercially important fish species/ groups to understand the dynamics and status of exploitation of fish stocks along Gujarat. Out of 52 fish stocks, 24 (46%) were in abundant status including stocks of catfishes, wolf herring, bombayduck, rock cods, threadfin breams, ribbonfishes, seerfishes, *T. tonggol*, soles, penaeid prawns and cephalopods, followed by 9 less abundant stocks (17%) like snappers, pig-facebreams, croakers, scads and black pomfret. Number of declining stocks were 17 (33%) comprising sharks, rays, *Coilia* sp., goatfishes, halfbeaks and fullbeaks, billfishes, unicorn cod, *Katsuwonus pelamis*, halibut and lobsters. Big-jawed jumper was in the depleted category (2%) and silverbellies were in collapsed state (2%).

Pelagic resources

Pelagic fishes with a landing of 2.86 lakh t formed nearly 38.8% of the total marine fish landing in Gujarat during 2016. The major pelagic resource was ribbonfish followed by Bombayduck, clupeids, seer fishes, tunas and carrangids. The mechanised multiday trawlnetters (43%) and the mechanised multiday dolnetters (38.5%) were the major gears that contributed to the pelagic landings. Nearly 92% of the Bombayduck landing was by the mechanised dolnet and nearly 82% of the ribbonfish landing was by the mchanised multiday trawlers alone. Outboard gillnetters (46%) and mechanised multiday gillnetters (30.5%) were the major gears that contributed to tuna fishery.

The dominant species were *Thunnus tonggol* (40.3%), *Euthynnus affinis* (33%), *Auxis* sp. (14%), *Katsuwonus pelamis* (4.4%) and *Thunnus albacares* (8.2%). *Megalaspis cordyla* formed 56.5% of the total carangid landings which was caught in many gears like trawls and gillnets. *Decapterus russelli* (27.5%) formed the next major species among the carangids and trawlers landed most of the catch (95%). Seerfishes formed only 3% of the pelagic resources landed and was mainly constituted by *Scomberomorus commerson* (48.3%) and *S. guttatus* (51.7%). Outboard gillnetters contributed 55% of the catch and the other major gears were multiday gillneters (18%) and multiday trawlers (25%). Clupeoids formed nearly 8% of the landings and the major species or groups were *Coilia dussumieri* (31%), *Thryssa* spp. (23%), *Ilisha megaloptera* (10%) and *Chirocentrus dorab* (14%).

Demersal resources

Demersal landings were estimated as 240052 t with 12.6% increase than previous year forming 31% of total production. Trawl contributed 75% of the total demersal catch being the highest followed by gillnets (14%) and dolnets (9.9%). Commercially important resources landed were threadfin breams (15.12%), catfishes (12.77%), lizardfish (9.19%), rockcod (8%), flatfishes (4.99%), sharks (3.45%), pomfrets (3.33%), and croakers (3.18%).

Biological parameters of important pelagic resources in Gujarat during 2016

Species	Length range (mm)	Mean length (mm)	Sex ratio (M:F)	Mature% (Female)	Average fecundity	Ova dia (mm)	Avg. ova dia.
Harpadon. nehereus	105-320	201	1.31	25.43	54327	0.36-0.79	0.57
Coryphaena hippurus	786-1990	927	11.00	100.00	350746	0.62-1.60	1.11
Coilia dussumieri	105-199	164	0.99	45.21	3803	0.42-0.51	0.47
Megalaspis cordyla	235-420	344	1.50	53.84	146400	0.39-0.63	0.51
Ribbonfish	160-1182	673	1.49	57.14	13750	1.50-7.21	4.36
Scomberomorus. guttatus	259-650	449	1.25	33.33	173430	0.79-0.96	0.88
Thunnus tonggol	400-820	618	0.85	38.88	207966	0.40-0.96	0.68
Euthynnus affinis	355-790	496	1.21	30.43	519336	—	0.60
Rastrelliger kanagurta	157-273	242	0.95	59.64	40928	—	0.71

Population parameters and biological reference points (BRPs) of commercially important pelagic resources in Gujarat (2012-2016)

Species	L∞ (mm)	K (yr-1)	M (yr-1)	F (yr-1)	Z (yr-1)	E	MSY	BMSY	FMSY
Euthynnus affinis	705	0.58	0.81	1.13	1.94	0.58	2017	4034	0.5
Megalaspis cordyla	518	0.72	0.88	1.23	2.11	0.58	5644	9763	0.58
Trichiurus lepturus	1186	0.38	0.56	1.22	1.78	0.69	128517	111332	1.15
Thunnus tonggol	1144	0.62	0.52	0.64	1.16	0.55	7688	14483	0.53
Coryphaena hippurus	1460	0.34	0.42	0.54	0.96	0.56	—	—	—

Threadfin breams contributed 15.12% to the total demersal landing. The fishery was supported predominantly by *Nemipterus japonicus* (59.75%) and *N. randalli* (40.25%). The estimated landing of croakers by multi-day trawlers, gillnetters and dolnetters was 7646 t contributing 3.18% to the total demersal landings. The dominant species in the trawl fishery was *Johnius glaucus* (47.12%), *Otolithes cuvieri* (35.72%), *Johnieops* sp. (9.12%), *Otolithoides biauritus* (5%) and *Protonibea diacanthus* (3.03%). Lizardfish formed 22077 t contributing 9.19% to the total demersal landing. The main species was *Saurida tumbil* (68%) followed by *S. undosquamis* (32%). Total pomfret production by trawls and gillnetters of Gujarat was 8006 t and formed 3.33% of the total demersal landing. The fishery was supported by *Pampus argenteus* (69.15%), *Parastromateus niger* (26.22%) and *Pampus chinensis* (4.6 %). Catfish landing of Gujarat was 30657 t which contributed 12.7% to the total demersal fish landing. Elasmobranchs formed 13882 t marked

by 6.06% increase compared to previous year. Elasmobranchs contributed 5.67% to the total demersal landings in Gujarat. Sharks dominated (60%) followed by rays (28%) and skates (12%). Shark catch was dominated by *Scoliodon laticaudus* (82.26%) followed by *Rhizoprionodon* sp. (5.36%), *Carcharhinus* sp. (5.10%), *Sphyrna* sp. (3.24%), *Galeocerdo cuvier* (1.47%), *Mustelus* sp. (1.25%), *Centrophorous* sp. (0.83%), *Isurus* sp. (0.34%) and *Alopias* sp. (0.11%). Skates were dominated by *Rhyncobatus* sp. (72.91%) and *Rhinobatos* sp. (27.0%). Similarly the rays were dominated by *Dasyatis* sp. 66.19% followed by *Mobula* spp. (30.13%) and *Himantura* sp. (3.60%).

Crustacean resources

Crustacean resources contributed 1.65 lakh t forming 21.25% of the total fish production from Gujarat during 2016. Compared to the previous year, crustacean landing showed an increase of 9.72%. Major groups in the crustacean landing were non-penaeid prawns (72%) followed by penaeid prawns (20%), crabs (6%), stomatopods (1%) and lobsters (1%). Major gears contributing to the crustacean landing were dolnet (68%) followed by multiday trawlnet (22%), mechanised trawlnet (8%) and gillnet (2%).

Prawns contributed about 1.52 lakh t forming about 92% of the total crustacean landings of Gujarat during 2016. Prawn landing showed an increase of 9.89% compared to the previous year. Non-penaeid prawns showed an increase of nearly 11.72% compared to previous year and

Biology of important demersal resources landed in Gujarat during 2016

Species	Length range (mm)	Mean length (mm)	Sex ratio (M:F)	Maturity (%)	Fecundity	Ova diameter
Saurida tumbil	144-470	284.09	1:1.36	43.00	10063-71364	0.312-852
Saurida undosquamis	96-209	222.54	1:1.61	50.41	6566-38388	0.291-0.521
Otolithes cuvieri	148-336	249.64	1:0.929	80.67	10520-153059	0.160-0.533
Johnius glaucus	109-295	201.3	1:1.38	96.11	5596-66139	0.202-0.806
Priacanthus hamrur	119-341	230.56	1:2.96	68.18	13133-81214	0.193-0.361
Muraenesox bagio	460-995	705.34	1:1.02	74.41	17475-144932	0.286-0.713
Parastromateus niger	95-570	169.06	1:1.78	41.46	1692-151796	0.176-0.482
Pampus argenteus	92-224	151.39	1:2.66	67.04	5470	0.398
Epinephelus diacanthus	104-506	220.33	1:4.3	20.93	4165-24765	0.118-0.248
Upeneus moluccensis	112-224	165.58	1:2.32	67.08	1515-61951	0.160-0.591
Nemipterus japonicus	108-280	161.85	1:2.29	46.74	17450	0.546
Nemipterus randalli	132-293	193.88	1:2.22	80.61	1213-17125	0.251-0.515
Arius tenuispinis	216-505	352.52	1:1.17	51.16	42-94	0.9-14.4
Scoliodon laticaudus	276-640	458.00	1:1.04	10.00	0	87.75

Growth and mortality parameters of selected commercially important demersal resources landed in Gujarat during 2016

Species	Linf (cm)	K (yr^{-1})	M(yr^{-1})	F (yr^{-1})	Z(yr^{-1})	E	L_r (cm)	$L_{c50\%}$ (cm)	$L_{m50\%}$ (cm)	Recruitment (peak)
Nemipterus japonicus	29.4	0.75	0.77	2.20	2.97	0.74	10.0	14.28	18.7	March-Sept
Johnius glaucus	30.45	0.54	0.62	1.29	1.90	0.62	10.0	25.70	19.5	May-Sept
Pampus argenteus	23.1	0.70	0.79	1.65	2.44	0.68	9.0	18.13	24.1	March-Aug
Arius tenuispinis	52.5	0.44	0.46	0.48	0.94	0.51	21.0	29.46	39.1	June-Oct
Scoliodon laticaudus	70.0	0.56	0.94	2.51	3.45	0.73	26.1	43.01	37.6	June-Oct

Biological reference points (BRPs) for the commercially important demersal resources landed in Gujarat during 2016

Species	E_{cur}	Y_{cur} (t)	Y^{cur} (million t)	F_{msy}	F_{mey}	$B_{0.5}$	$SSB_{0.20}$
Nemipterus japonicus	0.74	15378	28875	70	40	30	40
Johnius glaucus	0.62	18856	88276	120	80	40	80
Arius tenuispinis	0.68	11034	25289	80	200	20	80
Pampus argenteus	0.51	8234	10807	60	40	40	80
Scoliodon laticaudus	0.73	13715	72782	80	60	100	80

contributed about 1.18 lakh t forming 71.95% of total crustacean landing. Among the non-penaeid prawns, *Acetes indicus* dominated the catch (60.92%) followed by *Acetes japonicus* (25.73%), *Nematopalaemon tenuipis* (11.49%), *Exhippolysmata ensirostris* (1.84%) with very negligible landings of *Macrobrachium rosenbergii* and *Exopalaemon styliferus* (0.02%). Non-penaeid prawn resources were mainly exploited by dolnetters (83.42%) followed by singleday trawlers (8.87%), multiday trawlers (6.45%), gill netters (0.89%) and others (0.37%). Penaeid prawns showed a marginal increase of nearly 2.40 compared to previous year and contributed about 33227 t forming 20.19% of total crustacean landing. Among the penaeid prawns, *Parapenaeopsis* spp. (54.36%) dominated the catch followed by *Solenocera* spp. (22.92%), *Metapenaeus* spp. (13.28%), *Penaeus* spp. (8.84%) and *Metapenaeopsis* spp. (0.10%). Penaeid prawn resources were mainly exploited by multiday trawlers (61.72%) followed by dolnetters (30.91%) and singleday trawlers (3.74%).

Crabs contributed about 9714 t forming about 6% of the crustacean landings showing an increase of 3.92% compared to previous year. *Charybdis feriata* (79.06%) dominated followed by *Portunus sanguinolentus* (9.20%) and *Portunus pelagicus* (7.60%). Crabs were mainly exploited by multiday trawlers (73.39%) followed by dolnetters (10.26%), gillnetters (10.07%), singleday trawlers (2.05%) and others (4.23%).

Lobster catch was 1089 t forming about 1% of the crustacean landing. *Panulirus polyphagus* (75.90%) dominated followed by *Panulirus homarus* (18.51%) and *Thenus orientalis* (5.59%). Lobsters were mainly exploited by multiday trawlnetters (32.97%) followed by gillnetters (35.21%), dolnetters (28.96%) and singleday trawlers (2.86%).

Stomatopods contributed about 2128 t (1%) of the total crustacean landing, a decrease of about 12.61% compared to the previous year. The resource was solely contributed by *Oratosquilla* sp and mainly exploited by dolnetters (42.62%) followed by multiday trawlers (34.10%) and singleday trawlers (23.28%).

Molluscan resources

Cephalopods formed the major molluscan resource landed in Gujarat with landings of 61662.68 t forming 7.96% of the total landings. Cuttlefish (51%) dominated followed by squids (48%) and octopus (1%). Cuttlefish were dominated by *Sepia elliptica* (38%) and *Sepia pharaonis* (37%) and contribution from other species like *Sepiella inermis*, *Sepia prashadi*, *Sepia omani* and *Sepia kobiensis* were considerably marginal. *Uroteuthis (Photololigo) duvaucelii* recorded 66% and other squids including *Uroteuthis (Photololigo) singhalensis* contributed 34% of the total squid landings. Highest percentage of mature specimen occurred in *S. inermis* (75.5%) followed by *U. (P.) duvaucelii* (67.2%), *S. elliptica* (66.9%), *U. (P.) singhalensis* (62.3%) and *S. pharaonis* (44.4%). The diet components of the major cephalopods were fish as the preferable food item followed by prawn except for *S. inermis* where prawn was found to be the preferred diet than fish. Fish dominated more than 50% share of diet in both *S. pharaonis* (61%) and *U. (P.) duvaucelii* (56%). In case of *S. inermis*, prawns dominated (46%) followed by fish (56%) and crabs (23%).

Population structure of important crustacean species landed in Gujarat during 2016

Species	Sex	Length range (mm)	Mean length (mm)	Mode length (mm)	L_r (mm)	L_{c50} (mm)	L_{m50} (mm)	Sex ratio (M:F)
Solenocera crassicornis	Male	44-129	82.37	85.00	44.00	85.54	72.15	1.29
	Female	47-138	89.71	85.00	47.00	86.47	82.74	
Parapenaeopsis stylifera	Male	42-126	94.85	95.00	42.00	95.66	70.08	1.34
	Female	46-149	97.23	95.00	46.00	97.39	83.22	
Metapenaeus affinis	Male	83-173	131.55	135.00	83.00	127.82	93.28	1.21
	Female	85-191	137.04	140.00	85.00	129.09	109.47	
Metapenaeus monoceros	Male	86-199	146.35	145.00	86.00	143.51	105.40	1.25
	Female	85-226	150.02	140.00	85.00	136.64	121.33	
Penaeus semisulcatus	Male	88-208	154.54	160.00	88.00	156.43	107.21	1.27
	Female	84-237	160.38	160.00	84.00	151.25	126.39	

Growth, mortality and exploitation parameters of important crustacean species landed in Gujarat during 2012-16

Species	Sex	L_∞ (mm)	K (yr^{-1})	M (yr^{-1})	F (yr^{-1})	Z (yr^{-1})	E_{cur}
Solenocera crassicornis	Male	135.45	1.75	2.69	6.08	8.77	0.69
	Female	145.90	1.70	2.61	5.71	8.35	0.68
Parapenaeopsis stylifera	Male	132.30	1.70	2.61	4.07	6.23	0.65
	Female	156.45	1.60	2.46	5.85	8.56	0.68
Metapenaeus affinis	Male	181.75	1.65	2.53	5.45	8.22	0.66
	Female	200.55	1.60	2.46	4.15	6.94	0.60
Metapenaeus monoceros	Male	208.95	1.60	2.46	4.51	6.91	0.65
	Female	237.30	1.50	2.3	3.48	5.94	0.59
Penaeus semisulcatus	Male	218.40	1.55	2.38	5.57	8.91	0.63
	Female	248.85	1.50	2.3	5.15	8.45	0.61

Biological reference points (BRPs) for the important crustacean resources landed in Gujarat during 2012-16

Species	Sex	E_{cur}	Y_{cur} (t)	Y_{cur} (million t)	F_{msy}	F_{mey}	$B_{0.5}$	$SSB_{0.20}$
Solenocera crassicornis	Male	0.69	4692.92	464.55	4.0	1.6	0.8	1.2
	Female	0.68	6539.28	682.71	2.8	1.6	0.8	1.1
Parapenaeopsis stylifera	Male	0.65	5955.39	662.35	5.0	1.4	1.2	1.1
	Female	0.68	8005.58	955.22	2.2	1.2	0.7	1.1
Metapenaeus affinis	Male	0.66	1190.29	213.15	5.2	2.6	0.9	1.2
	Female	0.60	1508.55	377.23	3.8	2.0	0.9	1.3
Metapenaeus monoceros	Male	0.65	709.52	209.55	4.0	3.6	1.5	1.1
	Female	0.59	827.93	226.26	2.6	1.8	0.7	1.1
Penaeus semisulcatus	Male	0.63	294.64	159.72	4.4	3.8	1.6	1.0
	Female	0.61	344.15	227.75	3.0	2.4	0.8	1.3

Biology and growth parameters of imporatant cephalopod resources landed in Gujarat during 2016

Species	Min. length (mm)	Max. length (mm)	Mean length (mm)	L_r (mm)	L_{c50} (mm)	L_{m50} (mm)	K (yr^{-1})	Sex ratio (M:F)	% of mature specimen	a	b	R2
Uroteuthis (P.) duvaucelii	35	280	115.1	35.00	116.3	114	0.86	1:0.61	67.2	0.0004	2.45	0.94
Uroteuthis (P.) singhalensis	54	321	123.5	54.00	126.1	120	0.91	1:0.76	62.3	0.0086	1.82	0.82
Sepia pharaonis	66	330	176.4	66.00	180. 1	173	1.18	1:0.35	44.4	0.0023	2.81	0.95
Sepia elliptica	47	218	104.4	47.00	106.7	102	0.91	1:0.74	66.9	0.0491	1.65	0.79
Sepiella inermis	23	98	62.4	23.00	63.5	61	0.89	1:0.68	75.5	0.0026	2.34	0.79

Trawlnet catch at 10 m depth off Ratnagiri (September 2016)

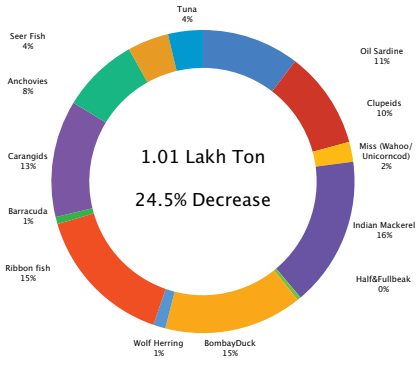
Maharashtra

Research Project: FISHCMFRISIL201201000010

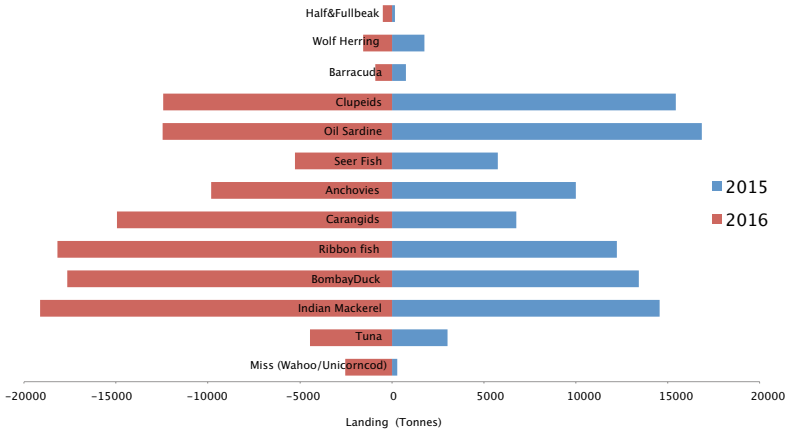
The estimated marine fish landings of Maharashtra during 2016 was 2.92 lakh t with 10% increase from previous year (2.65 t). Pelagic resources contributed major share with 41%, followed by demersals (26%), crustaceans (23%) and molluscs (9%). The major fishing gears that supported the fishery were trawlnet (56%), bagnet (20%), purseseine (16%), and gillnet (7%). Prominent species/groups that contributed to the fishery of the state were penaeid prawns (11%), non-penaeid prawns (10.7%), croakers (9.7%), Indian mackerel (6.5%), ribbonfish (6.2%), Bombayduck (6 %), threadfin breams (5%) and oilsardine (4.3%). The catch rates in purseseines remained the highest (131.4 kg h^{-1}) followed by shoreseine (53 kg h^{-1}), bagnet (36.6 kg h^{-1}), trawl (27.1 kg h^{-1}) and gillnet (10.2 kg h^{-1}).

Pelagic resources

Pelagic fishery contributed 41% to the total marine catch in Maharashtra. The catch increased from 1, 07,247 t to 1, 19,855 t registering 16% rise compared to 2015. Small pelagic fishes formed 1.02 t whereas large pelagics contributed 0.06 t in Maharashtra. Increase in the catch was due to increased landing of ribbonfish, Bombayduck, Indian mackerel and carangids. Major gears contributing to the pelagic fishery were purseseine (36%), trawlnet (35%), dolnet (17%), gillnets (11%) and others (1%). Indian Mackerel contributed 16% to the pelagic fish landing followed by ribbonfish (15%), Bombayduck (15%), carangids (12%), oilsardine (10%), golden anchovy (6%), seerfish (4%) and barracuda (1%).



Contribution by pelagic resources



Comparison of pelagic resources landings

Oilsardine: *Sardinella longiceps* formed 4.27% (12,473 t) to the overall fish production in Maharashtra. The species showed 26% decrease in the catch as compared to the previous year and purseseine was the major gear that caught *S. longiceps* (91.8%) followed by trawl 5.4%. The size range was 115-204 mm. Mature and gravid sardines were observed from January to May.

Golden anchovy : Golden anchovy *Coilia dussumieri* contributed 2.48% (7,237 t) to the total marine fish landings but recorded a decrease of 7% over previous year. Dolnet landings were 48% while trawlnets contributed 44.6% of the total catch. Gillnet contributed only 7%. The size range of *C. dussumieri* was 65-204 mm. Gravid specimens were seen in January to March, May, October and December.

Indian mackerel: With 19,123 t catch, the Indian mackerel *Rastrelliger kanagurta* contributed 6.5% forming the top most species amongst the pelagic resources in Maharashtra. Almost 62% of the mackerel landing in Maharashtra was contributed by purseseine followed by trawl (19%) and gillnets (18%). The size range was 120-289 mm. Almost all the females were in mature and gravid condition during February to March, October and December. Gut analysis revealed dominance of *Coscinodiscus* sp., copepods, foraminifera, *Biddulphia* sp. and *Pleurosigma* sp.

Bombayduck: With estimated catch of 17,657 t it formed nearly 6% of the total fish catch. Compared to last year Bombayduck catch increased by 32%. Dolnets contributed 67.8% of the catch followed by trawlers (31.9 %). Size class in the fishery ranged from 75 to 374 mm. Mature and gravid females were noticed during January, April, May, September and November.

Ribbonfish: Ribbonfish were about 6.22% (18,189 t) in the total fish catch of Maharashtra. An increase of 49% in the catch was observed in comparison to previous year. Trawlnet contributed the major share (86%) of this resource followed by dolnet (12%) and gillnet (1%).

Trichiurus lepturus was the dominant species with size range of 490-1189 mm. The occurrence of mature and gravid females was in January, March, November and December. Major food items observed were *Acetes* spp. (93%), *T. lepturus* (3.7%) and *Uroteuthis (Photololigo) duvaucelii* (2.7%).

Seerfishes: Seerfishes contributed 5,263 t (1.8 %) to the total catch and *S. commersoni* (77%) and *S. guttatus* (23%) were the only two species in the fishery. About 50.3% of *S. guttatus* was from gillnets followed by trawlnet (40.2%), purseseine (6.1%) and dolnet (3.3%). Size of *S. guttatus* ranged between 170-709 mm. Females in mature and gravid stages were noticed in May. Gut analysis showed *Acetes* spp. (51%), *T. lepturus* (38%), *Loligo* spp. (4.4%) and carangids (3.2%) as the major food items.

Barracuda: Barrcuda formed 903 t (0.3%) of the total catch. About 44.3% of the catch was from purseseine followed by trawlnet (41.7%), gillnet (11.8 %) and dolnet (2%).

Wolfherring: Wolf herring contributed 0.53% of the total fish landings. Trawlnet contributed 63% of the total catch followed by gillnet (28%). *Chirocentrus nudus* was the dominant species. Gut contents of *C. nudus* showed dominance of teleosts (67.10%) followed by *Acetes* spp. (8.59%) and cephalopods (8.45%). Sex ratio was 1:0.21 and 50% of the total analyzsed specimens were mature. The length mode was 421-440 mm.

Tuna: Tunas contributed 3.44% to the total pelagic catch and 1.41% to the total catch of Maharashtra. *E. affinis* contributed 73.82% followed by *T. tonggol* (12.78%).

Cobia: The estimated catch of *Rachycentron canadum* was 294 t in Maharashtra state. At Sassoon Docks estimated catch was 35 t at the catch rate of 0.02 kg h^{-1} forming about 0.1% of the total catch landed by trawlnets. Size range of *R. canadum* was 457-765 mm and sex ratio 1:0.57. Maturing specimens were recorded during December and January. The main food items were teleosts (76.03%) followed by crustaceans (12.42%) and cephalopods (5.58%).

Fullbeaks: Total catch of fullbeaks and halfbeaks in Maharashtra was estimated at 482 t forming only 0.4% of the total pelagic catch. *Ablennes hians* was caught by gillnets in commercial quantity. At Sassoon Dock 120 t of *A. hians* was landed, catch per hour being 0.33 kg. Sex ratio was 1:0.45. The length mode was 781-800 mm. Mature specimens were observed in May and March.

Billfishes/Sailfishes: Billfishes contributed 330 t (0.27%) to the pelagic fish landings. Gillnets contributed 80.89%, trawlnet 16.06% and purseseine 1.68% to the sailfish landings.

Demersal resources

Demersal landings were estimated at 0.76 lakh t (7.3% decrease from previous year) which formed 26% of total production. Croakers (37.2%) formed the dominant group followed by threadfin breams (19.1%), catfishes (10.9%), silver pomfret (6.7%), sharks (4%) rockcods (3.6%) and lizardfishes (3.4%). Sector-wise, trawlers contributed 78.9% followed by purseseiners (4.9%), multiday gillnetters (8%) and bagnetters (7.6%).

Croakers: Sciaenids contributed 28,334 t to total fish catch of Maharashtra. Trawlers, gillnetters, dolnetters and purseseiners contributed 25670, 1234, 908 and 385 t respectively and the catch rate (kg h^{-1}) was 4.2, 0.6, 0.6 and 1 respectively. Species that dominated fishery was *Johnius macrorhynus* (21.2%), *Johnius borneensis* (=*J. vogleri*) (21.1%) followed by *Otolithes cuvieri* (20%).

Nemipterids: Nemipterids were exploited exclusively by trawlers which amounted to14567 t with annual catch rate of 2.5 kg h^{-1} and contributed 5% to total fish landings. In comparison to previous year, Nemipterid catch increased by 17%. The major nemipterid species landed were *N. japonicus* (60.5%), *N. randalli* (32.1%) and *N. bipunctatus* (7.4%). *N. japonicus* and *N. randalli* mainly feeds on *Acetes* sp. and cephalopods. The size range of *N. japonicus* and *N. randalli* was 60-280 mm and 60-280 mm respectively.

Catfishes: Catfish catch along the Maharashtra coast was 8308 t, exploited mainly by trawlers, gillnetters, dolnetters, and purseseiners which contributed 2961, 1284, 1225 and 2788 t respectively. Annual catch rates (kg h^{-1}) were 0.49 in trawlnet, 0.80 in gillnet, 0.27 in dolnet and 45.4 in purseseine. Catfishes formed 5% of the total fish catch. Overall catch decreased by 38%. Contribution of this resource in trawlers, gillnetters, dolnetters and purseseiners was 36, 15, 15 and 37% respectively. Major species landed were *Osteogeneiosus militaris* (32%), *Plicofollis tennuispinis* (31%), *Nemapteryx caelata* (20%) and *Plicofollis dussumieri* (12%). Gravid females of *P. tennuispinis* were observed in May and that of *O. militaris* in the month of January and October.

False trevally: *Lactarius lactarius* catch along the Maharashtra coast was 770 t. Catch by trawlers, gillnetters, dolnetters, and non-mechanised sector was 629, 126, 7 and 0.5 t respectively. Contribution of this resource dominated in trawlnet (82%) followed by gillnet (16%). Size range in fishery was 50-270 mm and gravid females were observed during January, February and November

Rockcods: Rockcods were mainly landed by trawlers (2725 t) forming about 3.5% of the demersal catch at a catch rate of 0.4 kg h^{-1} in trawls. Catch decreased by 62% compared to previous year. Relative species abundance showed dominance of *Epinephelus diacanthus* (84%) followed by *E. tauvina* (9%), *E. latifasciatus* (5%) and *E. bleekeri* (0.9%). Almost 98.45% of *E. diacanthus* catch was dominated by juveniles and the length range was 110-320 mm.

Goatfish: Goatfishes were mainly landed by trawlers (991 t). Catch increased by over 35% from previous year. Relative abundance showed dominance of *Upeneus moluccensis* (95%) followed by *U. sulphureus* (4.61%) and *U. vittatus* (0.33%). *U. moluccensis* in the fishery was of size range 80-300 mm with mean size 169.59 mm and sex ratio 1:1.38. Major prey items observed were *Acetes* sp. and prawns.

Lizardfishes: An estimated 2567.3 t of lizardfishes were landed in Maharashtra dominantly in trawls. The catch rate was 0.42 kg h^{-1}. Catch increased by about 62% with *Saurida tumbil* (93.5%) dominating the fishery. Size range was 120-460 mm.

Pomfrets: 6700 t of pomfrets were exploited in Maharashtra, species landed being *Parastromateus niger* (21%), *Pampus argenteus* (76.5%) and *Pampus chinensis* (2.4%). The catch in trawl, gillnet and dolnet were 1512 t, 1872 t and 2953 t respectivey with catch per hour of 0.25, 0.94 and 1.85 kg respectively. *P. argenteus* was most dominant among pomfrets in dolnet (97%) followed by trawlnet (50%) and gillnet (78%). Black pomfret dominanted in purseseine catch (92%).

Polynemids: The estimated catch of polynemids was 1476 t, exploited by trawl (1052 t), gillnet (301 t) and dolnet (55 t) with catch per hour of 0.17, 0.15 and 0.03 kg respectively. Polynemid fishery was mainly supported by *Polydactylus mullani* (95%) in trawl, *Leptomelanosoma indicum* (73%) in gillnet and *Eleutheronema tetradactylum* (86%) in dolnet.

Elasmobranchs: Elasmobranchs catch was 3741 t which decreased by 16% compared to previous year. Catch comprised sharks (3030.5 t), rays (647.7 t) and guitarfishes (62.7 t). Elasmobranchs landings in trawlers, gillnetters and dolnetters were 2403.7, 1097.8 and 225.6 t, contributing 1.46, 5.42 and 0.39% respectively. Catch rates (kg h^{-1}) in these gears were 0.39, 0.55 and 0.14 respectively. Shark was the dominant group among elasmobranchs catch in all gears. *Scoliodon laticaudus* (91%) followed by *Rhizoprionodon oligolinx* (2.5%) were the dominant species of sharks in trawl. *Pateobatis bleekeri* was dominant among rays (52%) followed by *Brevitrygon imbricata* (18%).

Crustacean resources

The total crustacean landings of Maharashtra (66891.7 t) during 2016 showed 8.8% increase over 2015. Among the crustaceans, major contributors were penaeid prawns (32262 t; 48.2%), non-penaeid prawns (31159.9 t; 46.6%), stomatopods (1970.5 t; 2.9%), crabs (1221.5 t; 1.8%)

and lobsters (277.7 t; 0.4%). Crustaceans were mainly landed by trawlers (52.1%) and dolnetters (47.3%) with a catch rate of 5.72 and 19.84 kg h^{-1} respectively.

Prawns: Prawns formed 94.8% of the crustacean landings. Estimated penaeid prawn landing during 2016 was 32262.1 t (48.2%), Penaeid prawns were landed mainly by trawlnet 28010.7 t (86.8%) with a catch rate of 4.6 kg h^{-1} followed by dolnet 4047.4 t (12.5%), catch rate being 2.54 kg h^{-1}. In trawl, *Parapenaeopsis stylifera* contributed 29.08% followed by *Metapenaeus monoceros* (23.62%), *M. affinis* (20.81%), *S. crassicornis* (13.90%), *M. brevicornis* (2.15%), *P. sculptilis* (1.98%), *M. stridulans* (1.78%) and other species.

Estimated non-penaeid prawn landing during 2016 was 31159.9 t (46.6%) showing 35.5% increase over 2015. Major landings was by dolnet (27015.2 t; 86.7%) with a catch rate of 16.9 kg h^{-1} followed by trawlnet (4041.7 t; 13.0 %) with catch rate of 0.7 kg h^{-1}. Among non-penaeid landings in dolnetters, *N. tenuipes* contributed 62.6%, *Acetes* spp. 34.27% and *E. ensirostris* 3.12%.

Lobsters: Lobsters with estimated catch of 277.7 t formed 0.4% of the crustacean landings of Maharashtra showing a decline of 111.5% compared to 2015. Lobster landing was 86.3% by trawlers, 12% by gillnetters and 1.2% by dolnetters with a catch rate of 0.04, 0.02 and 0.002 kg h^{-1} respectively. Among lobsters landed by trawlers *Panulirus polyphagus* formed 99.19% and *Thenus unimaculatus* contributed 0.81%.

Crabs: Crabs with 1,491 t of catch formed 2.44% of the crustacean landings. Crabs were mostly landed by trawlers (70.05%) followed by dolnets (13.21%) and the rest 16.74% by other gears. Among the crabs landed by trawlers *Charybdis cruciata* contributed 51.88%, *P. sanguinolentus* 35.5%, *P. pelagicus* 3.21% and other crabs 9.41%.

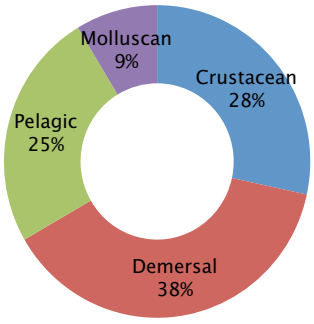
Molluscan resources

Total annual catch of cephalopods was 25939 t forming 8.87% of the total landings. Compared to previous year, catch increased by 41.25%. Squids dominated (21683.9 t) the catch. Trawl accounted for 98.2% of the catch (25477 t).

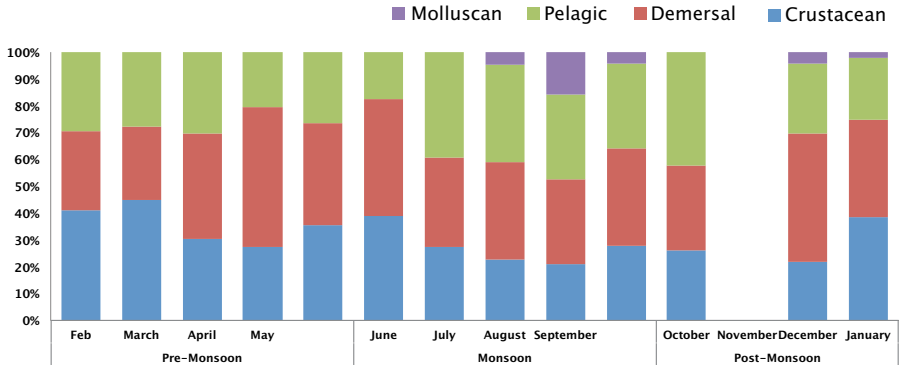
a. Bombayduck juveniles landed during monsoon
b. Juveniles of catfish landed in coastal dolnets during July
c. Pomfret catch in May
d. *Priacanthus prolixus* landed at Versova in July

*Uroteuthis (Photololigo) duvaucelii*landed at New Ferry Wharf

Trawlnet catch at 10 m depth off Ratnagiri (December 2016)



Seasonal group-wise species abundance in dolnet (Bokshi) at Mahul (Jan' 16 to Dec'16)



Percentage composition and abundance of fish groups in dolnet (Bokshi) at Mahul (Jan' 16 to Dec'16)

Fisheries environmental monitoring

In-situ monthly observations for environmental parameters were undertaken at 6 stations in Mumbai, which included 3 creeks and 3 near shore areas. The environmental changes were monitored during pre-monsoon, monsoon and post-monsoon seasons. Comparative observations were also conducted in 2 creeks and 3 inshore stations from Ratnagiri region. Phytoplankton analysed for seven stations along Mumbai coast, revealed that the density was

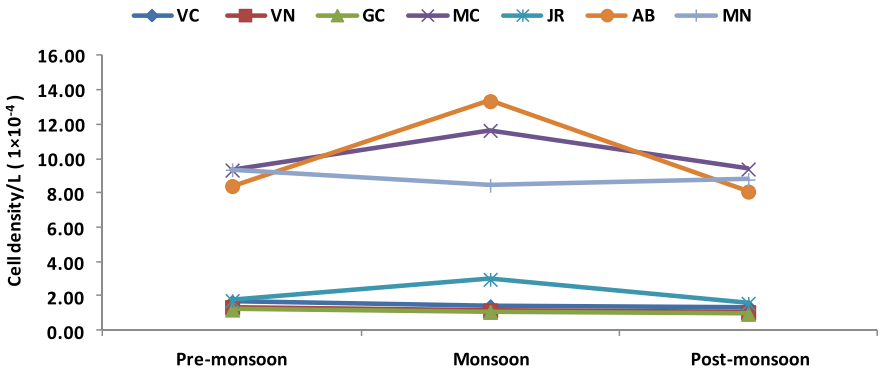
Seawater quality parameters in Mumbai (Jan-Dec, 2016)

Parameters	Range /Mean	Creek			Near shore		
		Pre-monsoon	Monsoon	Post-monsoon	Pre-monsoon	Monsoon	Post-monsoon
Air temperature (°C)	Min-Max mean	25.0-37.0 (33.4)	26.0-35.0 (30.0)	29.0-37.0 (32.8)	25.0-37.1 (32.6)	24.0-34.5 (30.4)	24.6-35.0 (30.0)
SST (°C)	Min-Max mean	23.6-32.8 (30.3)	26.0-33.0 (28.4)	24.8-29.8 (27.0)	23.3-32.8 (29.5)	25.4-32.3 (28.8)	24.0-35.0 (30.0)
Salinity (ppt)	Min-Max mean	3.2-34.2 (21.6)	0.5-33.5 (8.8)	12.9-33.8 (24.8)	24.6-35.5 (32.0)	2.0-34.3 (21.5)	28.8-34.8 (33.4)
Dissolved oxygen (mg l^{-1})	Min-Max mean	0.2-6.0 (2.3)	0.9-3.8 (2.4)	0.4-4.2 (1.7)	1.2-6.8 (3.2)	1.6-6.4 (4.1)	1.6-6.1 (3.1)
pH	Min-Max	6.4-8.13	6.7-8.4	6.5-8.3	6.4-8.5	6.4-8.3	7.2-8.4
BOD (mg l^{-1})	Min-Max mean	4.0-12.0 (7.5)	2.0-11.0 (7.9)	5.0-12.0 (8.2)	2.0-6.0 (3.3)	2.0-8.0 (4.5)	2.0-9.0 (4.5)
Chlorophyll-a (mg m^{-3})	Min-Max mean	3.5-9.9 (7.8)	4.2-26.9 (14.8)	2.5-16.5 (10.1)	0.16-14.7 (5.8)	0.8-10.7 (7.2)	5.0-15.4 (9.4)
Phosphate (mg l^{-1})	Min-Max mean	0.7-7.2 (2.0)	0.2-6.4 (1.4)	0.05-8.7 (4.1)	0.4-4.8 (1.8)	0.3-5.4 (1.7)	0.04-14.6 (2.3)
Nitrate (mg l^{-1})	Min-Max mean	3.2-7.8 (4.8)	1.4-7.2 (4.5)	1.8-14.5 (5.5)	2.7-5.6 (3.9)	2.1-9.9 (5.1)	1.6-14.6 (5.9)
Nitrite (mg l^{-1})	Min-Max mean	0.06-0.6 (0.1)	0.08-1.6 (0.38)	0.07-1.5 (0.4)	0.07-1.0 (0.2)	0.1-1.6 (0.4)	0.07-2.0 (0.7)
Silicate (mg l^{-1})	Min-Max mean	2.4-8.1 (4.5)	0.1-7.1 (2.0)	0.49-10.7 (6.5)	1.1-4.0 (2.8)	0.2-5.1 (2.0)	1.0-8.1 (2.9)
Ammonia (mg l^{-1})	Min-Max mean	0.3-1.8 (1.0)	0.06-1.2 (0.47)	0.06-3.6 (1.5)	0.06-1.0 (0.4)	0.09-1.1 (0.4)	0.03-1.0 (0.4)
Turbidity (NTU)	Min-Max mean	0.9-91.7 (21.9)	37.6-172.0 (78.8)	5.6-64.8 (27.9)	1.6-178 (46.8)	21.6-355.0 (91.2)	11.8-227.0 (59.1)
TSS (mg l^{-1})	Min-Max mean	0.08-0.7 (0.2)	0.3-0.7 (0.4)	0.12-0.5 (0.3)	0.12-0.7 (0.3)	0.04-0.6 (0.2)	0.06-0.66 (0.2)
TDS (ppt)	Min-Max mean	3.3-28.7 (11.2)	1.3-36.3 (8.4)	1.6-4.3 (2.5)	5.2-34.9 (18.0)	1.4-43.0 (16.4)	1.58-176.0 (34.7)

higher in Apollo bunder, Mahim Creek and Mahim nearshore compared with the other stations in Mumbai *viz.*, Versova Creek, Versova nearshore, Gorai Creek and Juhu nearshore. The highest number of species were recorded during June 2016 in Mahim Creek station. Dominant phytoplankton species observed were *Thalassiosira subtilis* followed by *Coscinodiscus granii, Navicula distans* and *Skeletonema costatum*.

Range of the seawater quality parameters in Mumbai (Jan-Dec, 2016)

Parameters	Depth		
	10 m	20 m	30 m
Air temperature (°C)	27.0-33.0	27.0-36.0	25.0-34.0
SST (°C)	25.3-29.7	26.5-29.4	25.0-29.6
Salinity (PPT)	32.04-35.3	32.6-35.4	31.6-35.2
Dissolved oxygen (mg l^{-1})	3.91-7.9	4.34-6.40	2.07-6.02
pH	8.2-8.77	8.12-8.71	8.23-8.70
BOD (mg l^{-1})	0-2	0.0-4.0	0-2
Chlorophyll-a (mg m^{-3})	5.73-6.81	4.50-5.09	4.98-6.89
Phosphate (mg l^{-1})	1.3-1.8	0.90-1.10	0.9-1.2
Nitrate (mg l^{-1})	2.71-4.9	6.42-8.3	5.31-6.1
Nitrite (mg l^{-1})	0.29-0.45	0.10-0.18	0.17-0.29
Silicate (mg- l^{-1})	3.01-3.80	2.35-3.09	1.29-1.86
Ammonia (mg l^{-1})	0.39-0.59	0.54-1.54	0.22-0.36
Turbidity (NTU)	8.58-33.2	4.14-14.75	1.84-3.85
TSS (mg l^{-1})	0.154-0.414	0.23-0.36	0.21-0.26
TDS (ppt)	6.25-28.9	5.98-33.93	6.12-35.49
E. coli (cfu ml^{-1})	Trace – 102	Nil	Nil
TVC (cfu ml^{-1})	102 – 104	Trace – 102	Nil
TCF (cfu ml^{-1})	Trace – 102	Nil	Nil

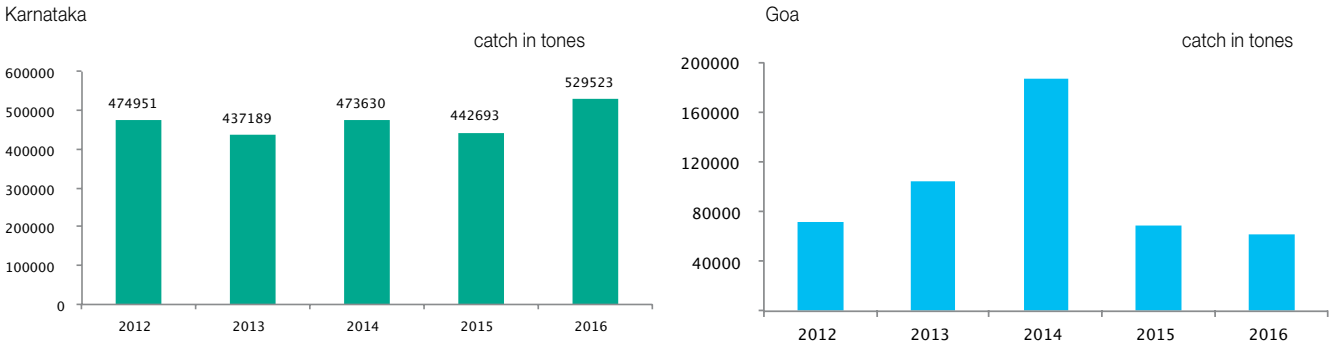


Seasonal abundance of phytoplankton species along Mumbai coast

Karnataka and Goa

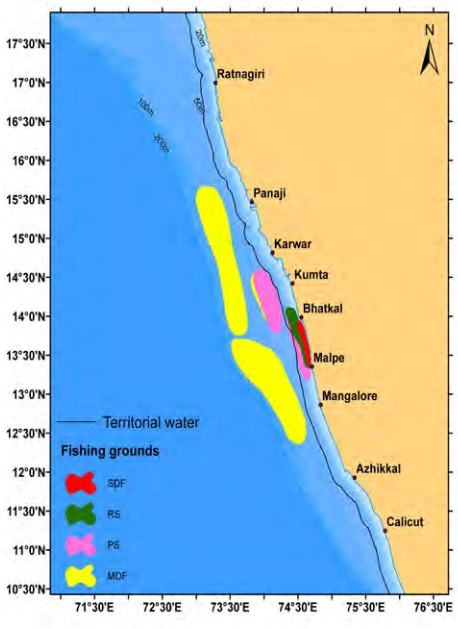
Research Project: FISHCMFRISIL201200600006

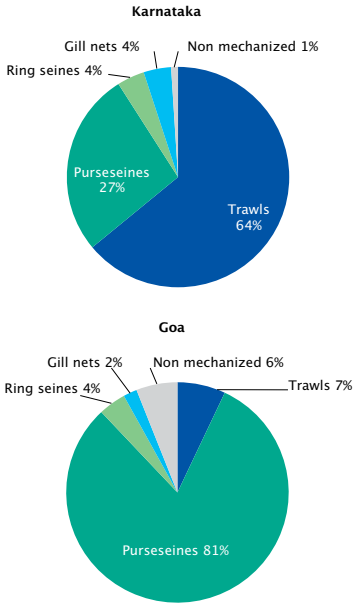
Total estimated marine fish catch (5,29,523 t) in Karnataka registered an all-time high and crossed five lakh t for the first time in 2016 and was 19.6% higher than that recorded in the previous year. In Goa, the catch (61,219 t) during 2016 however registered a decline of 10.73% as compared to 2015. The total catch in Karnataka during 2016 was also 12.38% above the five year average (2012-2016) of Karnataka. In Goa the catch during the year was 60.98% below the five year average. The production per km of coast was estimated as 1765 t and 650 t for Karnataka and Goa respectively. The total fishery during 2016 at landing centre level was valued at an estimated ₹ 4620 crores in Karnataka



Trends in total marine fish landings in Karnataka and Goa (2012-2016)

The extent of fishing area by different gears was mapped. The non-mechanised sector operated close to the shore within 12 nm (2 to 8 m depths). The multi-night trawlers operated beyond 12 nm (10 to beyond 200 m) and operation spread from Kerala to Maharashtra. Purseseine operation was off Karnataka at depths ranging from 10 to 90 m and that of gillnets at depths ranging from 20 to beyond 100 m. Purse seines with lights (light fishing) operated beyond 50 m depth.





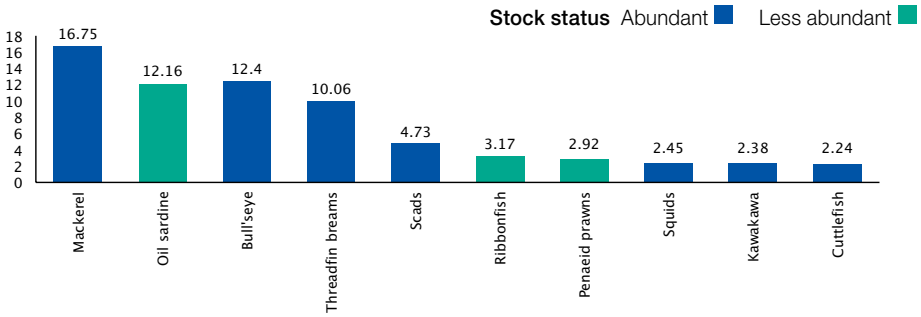
a. Operational area of selected commercial fishing gears in Mangaluru, Gangolli and Bhatkal
b. Contribution (%) of different sectors to the total marine fish landing in Karnataka and Goa

Trawlers and purse-seiners comprised the mechanised sector, the ringseines and gillnets the motorised sector and the other minor gears formed the non-motorised sector.

Stock status of major resources

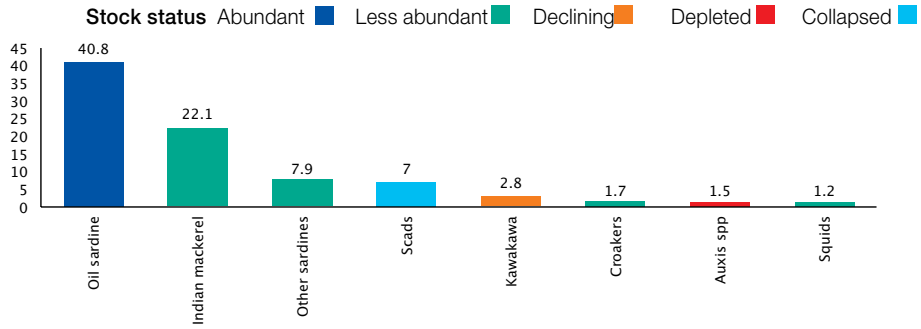
Mackerel formed the dominant fish in Karnataka and oil sardine in Goa. Of the 45 groups studied for the stock status In Karnataka, 23 were abundant, 13 less abundant and 9 in declining state. In Goa, the oil sardine was in abundant state and tunas in less abundant state.

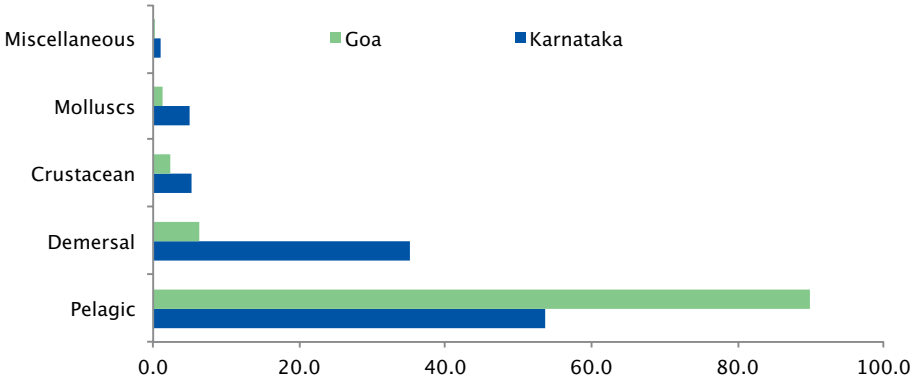
Dominant groups contributing (%) to the fishery in Karnataka



Indian Mackerel landings at Mangalore Harbour

Dominant groups contributing (%) to the fishery in Goa

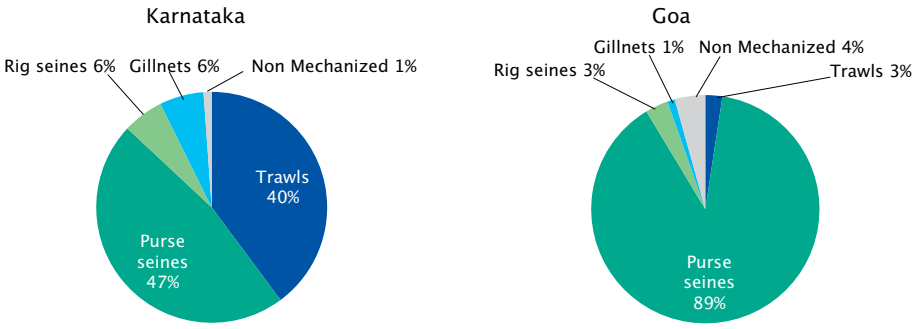




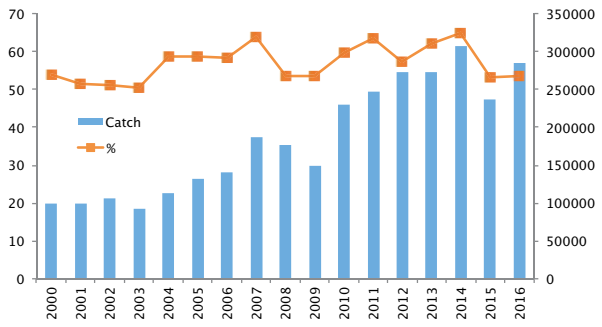
Contribution of different groups to total fish landings in Karnataka and Goa during 2016

Pelagic resources

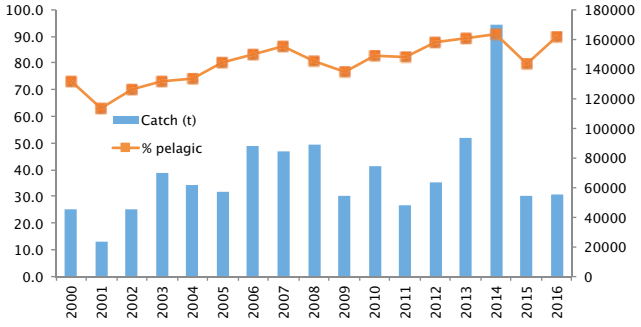
Pelagic fishes with an estimated catch of 2,84,482 t comprised 53.7% registering , an increase of 20.5% during 2016. In Goa, the group formed 89.9% (55006 t).



Gearwise contribution to the total marine fish landing in Karnataka and Goa



Annual trends of pelagic fish landings in Karnataka and contribution (%) to total marine catch



Annual trends of pelagic fish landings in Goa and contribution (%) to total marine catch

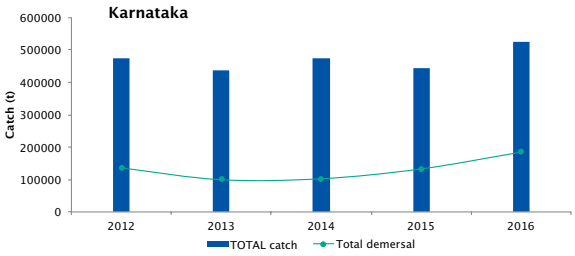
Preparation of ringseine for mansoon fishing at Malpe

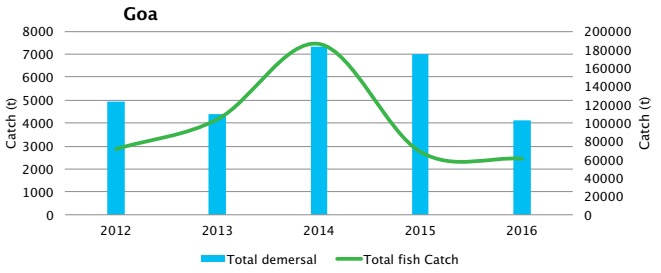
Stock status of major demersal resources in Karnataka

Species/Stock	Stock status
Catfish	Abundant
L. lactarius	Abundant
Lizardfish	Abundant
Threadfin breams	Abundant
Silverbellies	Less Abundant
Pomfrets	Abundant
Rockcods	Less Abundant
Elasmobranchs	Abundant
Soles	Declining

Demersal resources

The demersal fishes with an estimated catch of 1,85,547 t formed 35% of the total catch in Karnataka and 6.4% (3892 t) in Goa.





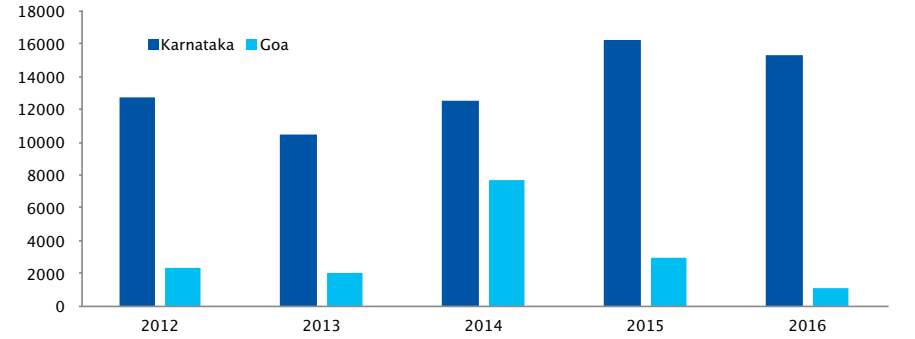
a. Catfish landings observed in Mangalore
b. Catch of bull's eye

Crustacean resources

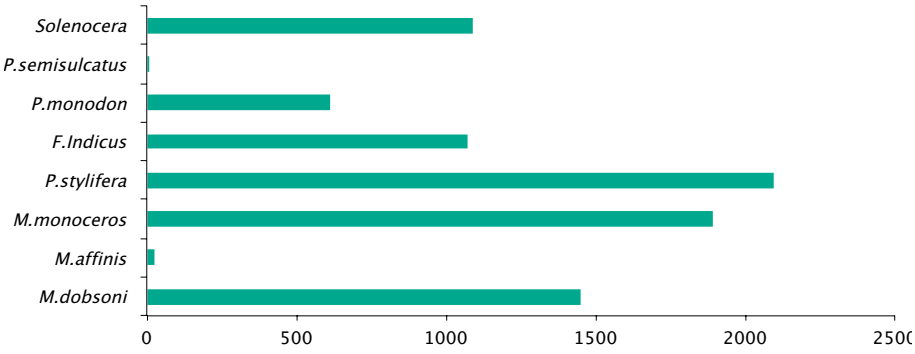
An estimated 27,749 t of crustaceans (penaeid prawns 15292 t, crabs 4415 t and stomatopods 8028 t) were landed forming 5.2% of total catch in Karnataka. In Goa, 1461 t of crustaceans (penaeid prawns 1093 t), crabs 257 t and stomatopods 111 t) were recorded registering a decline of 63.2%.

Major share of the landings was contributed by trawls, which registered a 68% decline. Ringseines and purseseines contributed the rest of the catch. The prawn catch decreased by 5.7%. The major prawn species in trawl were *Parapenaeopsis stylifera*, *Metapenaeus monoceros*, *Metapenaeus dobsoni*, *Fenneropenaeus indicus*, *Penaeus monodon*, *Metapenaeus affinis* and *Solenocera choprai*.

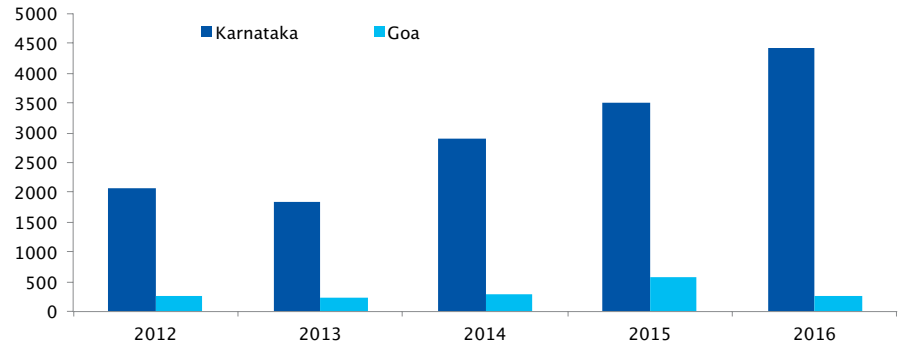
Crab landing of Karnataka in 2016 was 4415 t, an increase of 26%. In Goa an estimated 257 t was recorded. *Portunus sanguinolentus*, *Charybdis feriatus* and *Portunus pelagicus* were the major species in the fishery.



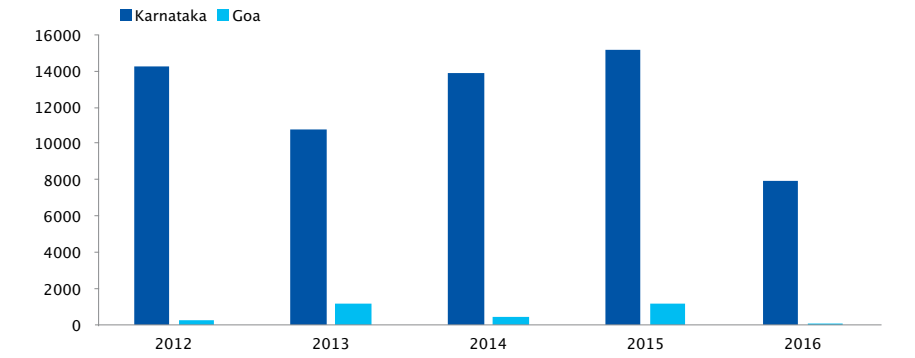
Penaeid prawn landings in Karnataka and Goa



Species composition of prawns in trawls

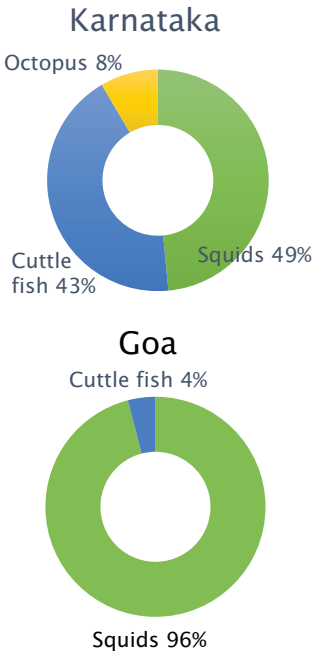


Species of prawns in trawls



Stomatopod landings

a. Prawns catch in Karnataka
b. Mixed catch landed during monsoon being sorted at Malpe Fishing Harbour
c. Crab landings



Groupwise (%) Cephalopod landings in Karnataka and Goa

Species composition of Cephalopod groups

Speceis	%
Squids	
U. (P.) duvaucelii	38
U.(P.) singhalensis	2
U.(P.) edulis	9
Cuttlefish	
S. pharaonis	29
S. elliptica	9
S. inermis	4
Octopus	
A. neglectus	5
O. indicus	3

Stock status of cephalopods in Karnataka

Resource	Stock status
Squids	Abundant
Cuttlefish	Abundant
Octopus	Abundant

Stomatopods with a catch of 8020 t comprised 1.5% of the catch in Karnataka, registering a decline of 46.9%. In Goa the catch of 111 t formed 0.2% of total landings.

Length range, mean and sex ratio of important resources studied

Species	Length range (cm)	Mean	Sex ratio (M:F)
Fishes			
S. longiceps	7.5-20.5	14.8	1:1.4
S. fimbriata	10.5-19.5	16.1	1:1.2
S. gibbosa	10.2-18.9	15.3	1:1.02
S. albella	11.8-18.2	15.3	1:0.9
R. kanagurta	4.7-29.5	18.4	1:0.84
T. lepturus	13.5-46.1*	22.0	1:0.99
E. devisi	3.9-10.8	9.2	1:0.6
R. canadum	10.0-162.0	50.0	1:1.5
S. commerson	16.0-128.0	56.0	1:0.8
E. affinis	16.0-78.0	36.0	1:1.9
A. thazard	30.0-42.0	35.0	1:0.8
S. obtusata	10.0-38.0	23.0	1:0.9
S. putnamae	120-1000	39.4	1:1.3
S. jello	14.0-138.0	41.0	1:2.8
S. barracuda	60.0-133.0	93.8	1:1.5
S. commersonianus	22.0-108.0	45.0	1:1.2
S. tol	16.0-56.0	32.0	1:0.9
S. tala	20.0-64.0	30.0	1:1.9
S. lysan	32.0-70.0	41.8	1:1
S. nigrofaciata	17.2-64.0	30.8	1:0.91
C. hippurus	20.0-114.0	61.0	1:4.0
A. hains	58.0-114.0	77.0	1:1.6
S. strongylura	58.0-114.0	111.0	1:1
M. cordyla	10.9-40.9	26.6	1:1.35
D. russelli	10.0-19.0	18.9	1:1.3
N. japonicus	5.0-34.0	17.0	1:1
N. randalli	4.0-31.0	12.7	1:0.5
L. lactarius	4.0-29.0	14.5	1:0.6
P. argenteus	10.0-30.0	19.9	1:0.6
P. niger	10.0-50.0	22.2	1:1.1
L. inermis	10.0-50.0	24.2	1:0.7
P. erumei	17.0-63.0	28.2	1:0.7
I. omanensis	26.0-63.0	37.5	1:.4
Crustaceans			
M. dobsoni	5.3-12.3	8.8	1:1.58
P. stylifera	4.3-11.3	8.85	1:1.43
M. monoceros	7.3-17.8	12.86	1:1.1
S. choprai	5.8-11.8	9.27	1:0.92
Cephalopods			
U. (P.) duvauceli	3.0-30.0	10.8	
U. (P.) singalensis	4.5-34.5	10.4	
U. (P.) edulis	3.0-33.5	8.9	
S. pharaonis	8.0-42.0	19.6	
S. elliptica	2.5-16.5	7.6	
S. prashadi	11.0-32.0	18.9	
S. inermis	2.5-12.5	5.4	
S. trygonina	9.0-20.0	17.1	
A. neglectus	2.5-9.5	5.1	
O. dollfusi	3.0-18.0	4.0	

*Anal length

Estimated growth parameters of important resources

Speceis	K	L_∞	W_∞	a	b	L_{max}	t_m	t_0	L_m	L_m/L_∞
S. longiceps	1.550	23.16	95	0.0119	2.860	20.5	1.90	-0.1124	15.00	0.65
E. devisi	1.590	11.70	9	0.0238	2.409	10.8	1.90	-0.0660	6.80	0.58
R. kanagurta	1.634	33.28	460	0.0045	3.291	29.5	1.80	-0.0833	17.50	0.53
T. lepturus	0.820	134.0	1672	0.0006	3.030	130.0	3.70	0.0720	60.00	0.45
S. commerson	1.25	168.50	284274	0.1542	2.814	128	2.40	-0.0724	70.00	0.42
E. affinis	0.560	89.20	10951	0.0254	2.889	78.0	5.30	-0.0317	37.70	0.42
A. thazard	1.20	58.70	4471	0.0033	3.467	48.0	2.50	-0.0075	29.70	0.51
N. japonicus	0.86	36.9	0.00386	2.664	-0.1026	21.3	0.58			
N. randalli	0.87	32.72	0.0265	2.7855	-0.105	19.1	0.58			
L. lactarius	1.16	33.91	0.0157	2.9034	-0.0769	19.8	0.58			
P. argenteus	0.55	32.5	0.024024	2.8779	-0.1466	19.0	0.58			
P. niger	0.36	58.3	0.0322	3.01	-0.152	32.2	0.55			
L. inermis	0.53	54.0	0.0187	2.8676	-0.1301	30.0	0.55			
l.omanensis	0.48	107.6	0.001719	3.151	-0.001719	55.7	0.52			
M. dobsoni	1.33	12.6	13.4	0.0076	2.95	12.4	0.62	7.1	0.56	
M. monoceros	1.55	21.0	79.5	0.0040	3.251	20.4	0.51	11.6	0.55	
P. stylifera	1.44	13.1	13.3	0.0110	2.7579	12.8	0.66	8.0	0.60	
S. choprai	1.8	12.6	27.1	0.0114	3.0682	12.3	0.41	6.5	0.52	
P. pelagicus	1.5	16.3	281.3	0.0234	3.3658	16.0	0.59	9.6	0.59	
P. sanguinolentus	1.25	17.1	282.9	0.0474	3.0624	17.0	0.61	8.96	0.53	
C. feriatus	1.3	17.6	282.9	0.0374	3.01	16.8	0.61	8.96	0.51	

Estimated population and stock parameters of important resources

Species	Z	M	F	E	L_{opt}	SSB (t)	St.SB (t)	Yield	MSY	Recruit. no.
S. longiceps	5.79	2.747015	3.05	0.74	15.2	163445	491537	783490	1423000	137760027
E. devisi	8.60	2.806027	5.79	0.78	6.6	14645	24666	37105	106063.8	41659628
R. kanagurta	4.64	2.87094	2.77	0.68	17.90	95023	166875	440659	387150	22302558
T. lepturus	5.85	1.670046	4.25	0.73	65.4	5400527	9140728	14721148	26736629	262807550
S. commerson	6.61	2.304425	4.31	0.76	77.0	1004.22	4555.83	30606.84	15057.02	5258
E. affinis	6.58	1.286468	5.30	0.72	39.3	7664	9074	2529	29853.46	10683
A. thazard	6.32	2.23066	4.19	0.45	31.2	459	508	290	1605.28	1643
N. japonicus	4.08	1.73	2.35	0.58	22.8	6147.96	22361	19411		
N. randalli	4.35	1.75	2.61	0.6	19.6	4098	36253	30327		
L.lactarius	4.18	2.17	2.01	0.48	20.4	65.53	2921	3037		
P.argenteus	2.42	1.27	1.15	0.48	19.2	2379	577	607		
P. niger	1.19	0.99	0.2	0.17	34.0	1807	2373	7060		
L.inermis	2.43	1.24	1.19	0.49	31.5	1267	5112	5219		
l. omanensis	3.6	1.169	2.43	0.68						
M. dobsoni	6.77	2.42	4.54	0.65	7.8	496.38	1125.37	2986.03	2168	2422590
M. monoceros	6.95	2.75	4.15	0.6	13.2	652.43	1173.79	3562.55	2948	574228
P. stylifera	8.16	2.58	5.46	0.68	8.2	469.34	1231.61	2157.5	1578	1900282
S. choprai	10.07	3.12	7.84	0.72	8.0	226.05	276.02	731.4	516	275704

Molluscan resources

Comprised mainly of cephalopods (cuttlefish, squids, octopus), bivalves (clams, mussels and oysters) and gastropods. Cephalopods with a catch of 26604 t formed 5% of total catch in Karnataka and 740 t and 1.2% respectively in Goa. Comparison of growth of *U. (P.) singhalensis* using hard parts with conventional methods, indicated higher growth rate.

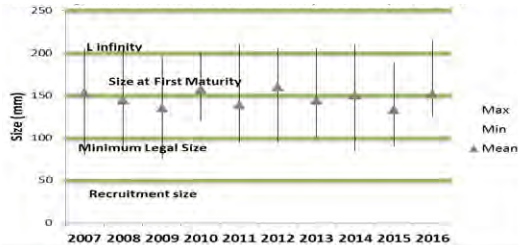
The optimum fleet strength for different categories of craft gear combinations operating in Karnataka was estimated as: multiday trawlers - 1312, single-day trawlers - 729, purse-seiners - 182 and motorised crafts - 2330. Large scale operation of pelagic trawls as well as light fishing by purse seiners during the year accounted for the increase in total catch and resulted in landings of several groups of fishes with no specific gear-resource combination. Mananagement measures were adopted such as issuance of order banning the operation of pair/bull trawling and memorandum issued by DADF on light fishing by purse seines based on advisories provided.

Kerala and Lakshadweep

Research Project: FISHCMFRISIL201200300003

In Kerala the marine fish landings during 2016 was 5.22 lakh t showing an increase of 7%; pelagics contributed 61%, demersals 25%, crustaceans and molluscs 7% each. Though oilsardine landing continued its downward trend, pelagic fish landings improved marginally mainly due to heavy catches of scads

Oilsardine: Catches along Kerala coast registered a decline during 2016 with an estimated landing of 43492 t constituted by the size group 12-15 cm with 57% below L_m. The serious retardation of the normal spawning and recruitment process observed in 2015 seemed to have subsided with fishes having gonads in various developing stages



Size range and mean size of Oilsardine landed at Kochi during 2007-2016

Possible reasons for oilsardine decline in the fishery
In 2012 and 2013, SSB was 61% and 37% of the TSS but recruitment to the fishery was poor.
Since 2014, further indications of poor feeding and poor condition of fish during the normal spawning period of May -July.
In 2015, the oilsardine landed all along the central Kerala belt showed signs of poor feeding and delayed process of maturation of gonads
Spawners normally abundant in the landings during the June-August period were not observed indicating serious retardation of the normal spawning and recruitment process.
During January-March, 2016 maturing sardines started appearing in the fishery and indicated a normal maturation process.
The spawning stock biomass indicated 31% (by weight) of the total standing stock and Relative Fecundity (eggs/gram body weight) during the last quarter of the year 2015 indicated 700 - 800 range suggesting that egg production for the recruitment process is likely to be better if favorable environmental factors like a normal monsoon prevail.
Number of spawners available in the fishing grounds were low.

observed regularly. Mature and spawning fish were noticed during May-June and October-November period.

Mackerel: A total of 47020 t of mackerel *Rastrelliger kanagurta* was landed contributing to 9% of the total fish landings along Kerala coast in 2016 indicating a strong decline in landings. Outboard and mechanised ringseines accounted for 31% and 20% while multiday trawl nets landed 24%. Extended spawning as observed from availability of fully mature fishes during January-June period with peak during January-May was recorded during the year. Less than 0.1% of estimated numbers in the landings off Kochi were below Minimum Legal Size (140 mm) while 27% of estimated numbers were below size at first maturity (190 mm).

Anchovies: *Stolephorus* spp. formed the major pelagic resource and the landing was 35467 t forming 7% of the estimated total marine fish landings. Ringseines accounted for 80% of the catch while multiday trawls contributed about 14% of the landings and rest (6%) by other gears. *S. commersonii* (70-120 mm size range), *S. baganensis* (50-80 mm), *S. indicus* (110-160 mm) and *E. devisi* (75-100 mm) were observed in catches off Kochi. *E. devisi* dominated in ringseine landings off Alappuzha.

Carangids: Contributed 15% of marine fish production of the state. Fishery improved by 75% during the year, due to improved landing of *Decapterus* spp. Thirtytwo species were seen in the fishery and the major components were scads (70.2%), horse mackerel, trevallies and leatherjackets. Young ones of most species were encountered in coastal fishery round the year with peak abundance during south-west monsoon period. Mean size of the species in the catch was larger than size at maturity, indicating healthy fishing conditions. More than 50% of the catch of the above species were matured or spent individuals, indicating that large proportion of the stock spawned before they were caught.

Seerfishes: Fishery occurred round the year with peak during October-November and February. Fishery was supported by three species with major contribution by kingseer, *Scomberomores commerson* (84%), *Scomberomorus guttatus* (11.7%) and *Acanthocybium solandri* (4.3%). Landings of *A. solandri* showed wide fluctuation over the season, while *S. guttatus* landings restricted to northern districts. Catch of *A. solandri* was supported by 82-146 cm fishes in hooks and line/gillnets. The mean size and also the length at capture of kingseer in gillnet-hooks and line were larger than size at maturity.

Tuna: Tuna landings along the coast registered improvement (31%) during the year. They were caught mainly by drift gillnets and hooks and line. Small quantity was landed by ringseine/ purseseines and trawls. Fishery occurred round the year with peak during August-January. However, young ones of coastal tunas were landed manly during June-September by ringseines

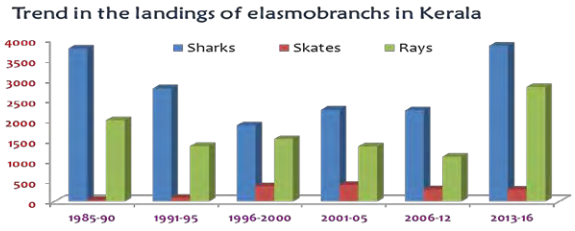
Impact assessment of Ring seine on the fisheries

Ringseine being a non-selective gear for size and juveniles of many species form sizeable proportion of gear's catch, responsible fishing by adopting of CCRF will help minimising the impact of the gear.

- Size of the ring seine needed to be standardised
- Engine power should be standardised and restricted
- Present fleet size is much higher than the estimated optimum fleet size for ringseines. Over capacity both in number and fishing power needed to be trimmed.
- Number of fishing trips/units/ per season or total allowable catch to be implemented

and trawls. Nine species supported the fishery comprising five coastal/neritic species and four oceanic species. Coastal species constituted 51% of the tuna catch and was dominated by *Euthynnus affinis* (30.5%). Other species in the fishery were *Auxis thazard*, *Auxis rochei*, *Sarda orientalis* and *Thunnus tonggol*. Catch of all species of coastal/neritic tuna improved. Stock assessment of coastal tunas indicated that most species are exploited either optimally or slightly above the optimum level. This necessitates cautious approach to maintain the stock and yield at optimum level or slightly below it.

Elasmobranchs: In Kerala, 8571 t of elasmobranchs was landed (2016); of this, 4767 t was sharks, 3714 t rays and 83 t was guitarfishes. Twenty species of sharks were observed in MDNHL at Cochin Fisheries Harbour, with major contributions by *Carcharhinus falciformis* (34.5%), *C. longimanus* (11%), *Alopias superciliosus* (6%), *A. pelagicus* (7%), *Galeocerdo cuvier* (7%), *Sphyrna lewini* (6%), *Carcharhinus leucas* (5%), *Isurus oxyrinchus* (6%), *C. brevipinna* (2.5%), *C. limbatus* (2%) *Triaenodon obesus* (2%) and *Carcharhinus sorrah* (1%). Landing of huge mobulid rays caught by tuna long lines, which were operated for skipjack tuna were observed at Cochin Fisheries Harbour. These rays were caught off Ratnagiri coast at a depth of 500 m and weighed around 350-400 kg each. The landing of rays has increased considerably



Landings of sharks at Cochin Fisheries Harbour

compared to the previous years. Landings of *Mobula japanica* and *Mobula tarpacana* have decreased while landings of *Himatura fai* was high during 2016. Gills and meat were traded fully and only the gut was discarded.

Groupers and snappers: Groupers contributed 32.3% of the total marine landings with a CPUE of 515.82 kg. Eighteen species of groupers were landed in Kerala on a commercial level. *Epinephelus diacanthus* was dominant in trawls; while the pattern in the hooks and line showed a variation based on the area of operation over the years. During 2016, length range of *E. diacanthus* in the fishery was 131-520 mm with maturing ones occurring in May. Mean length in the fishery fluctuated between 235 to 360 mm. Recruitment into the fishery was seen during August. Fishery has also improved over the years and seen to be in a healthy state.

An estimated 1611 t of snappers was landed during the year contributed by 20 species. Major contributors to the commercial landings were *Pristipomoides typus, P. multidens, P. filamentosus, Lutjanus vitta, Lutjanus kasmira, L. bohar, L. lutjanus, L. argentimaculatus, L. rivulatus, Aprion virescens, Paracaesio sordida, Pinjalo pinjalo* and *Pinjalo lewisi*. Length range of *P. filamentosus* in the fishery was 19-84 cm with recruitment during August.

Threadfin breams: During the period 2012-2016 a total of 2,04,076 t of threadfin breams were landed in Kerala.. *Nemipterus randalli* (54%) and *Nemipterus japonicus* (43%) mainly

Landings of groupers at Cochin Fisheries Harbour

contributed to the bulk of the catch and *Nemipterus bipunctatus* was landed in small quantities. Peak spawning period of *N. randalli* was observed during June-October. Exploitation rate was 0.72 indicating that it is exploited above the optimum level. Spawning stock biomass formed 71% of the standing stock biomass. Total yield estimated along the Kerala coast was 21933 t. Peak period of spawning of *N. japonicus* was observed during September-December.

Lizardfishes: Contributed 4.76% to the total marine fish landings of Kerala. Fishery occurred throughout the year with peak landings during August. Peak breeding season for *S. undosquamis* was during November- March and that of *S. tumbil* was September-February.

Bull's eye: The estimated total landings of *Priacanthus* spp. during the year was 29068 t which contributed 2.6% of the total marine landings of Kerala. The major species in the commercial fishery were *Priacanthus hamrur* (86%), *Cookeolus japonicus* (12%), *Priacanthus sagittarius* and *Heteropriacanthus cruentatus* (1% each).

a. Juvenile landing of Threadfin breams
b. Landings of Lizard fishes
c. Heavy landing of Bulls eye at Munambam Harbour

Resources/ Species/stock	Stock status
Stolephorus	Abundant
Thryssa	Abundant
Lizardfish	Abundant
Groupers	Abundant
Threadfin bream	Abundant
Croakers	Abundant
Ribbon fish	Abundant
Scad	Abundant
Mackerel	Abundant
Black Pomfret	Abundant
Chinese Pomfret	Abundant
H. gibbosus	Abundant
M. andamanensis	Abundant
Sepia pharaonis	Abundant
Sepiella inermis	Abundant
Uroteuthis (P.) duvaucelii	Abundant
Rays	Less Abundant
Silverbellies	Less Abundant
Bigjawed Jumper	Less Abundant
A. alcocki	Less Abundant
H. woodmasoni	Less Abundant
S. prashadi	Less abundant
U.(P.) edulis	Declining
U.(P.) singhalensis	Declining
Sepioteuthis lessoniana	Declining
Amphioctopus neglectus	Declining
A. marginatus	Declining
Cistopus indicus	Declining
S. elliptica	Declining
Snappers	Declining
Catfish	Declining
P. quasigrandis	Declining
Thenus unimaculatus	Declining

Pigface breams: A total of 256 t of pigface breams contributing 0.8% of the total landings was landed which was 33% lower than 2015. Peak landings was observed during March (15.5%).

Pufferfishes: During the year 188 t of pufferfishes was landed. Catches have declined by 559 t during the period 2012-16. *Lagocephalus inermis* was the major species observed in the pufferfish landings

Flatfishes: Flatfishes contributed 9075 t during 2016. Landings have shown a sharp decline since 2012 in Kerala. *Cynoglossus macrostomus* which once formed 98% of the Malabar flatfish fishery has decreased to 78% of the landings. Landings of *Psettodes erumei* was absent during the year; the other species landed were *C. bilineatus* (10.8%) *C. macrolepidotus* (10.7%); *Synaptura commersoniana*, *Zebrias quagga* and *Zebrias synapturoides* (5%) (brackishwater). Mean size in the fishery increased from 115-123 mm during the period 2012-2016 and recruitment was during July -September.

Malabar fishery: Fish catches in North Kerala has been showing a declining trend from 2012 onwards. Many of the units remained idle, but few of them survived by resorting to mackerel in the beginning and whitebaits in the later part of the season. *Scomber indicus* new species which appeared along the Malabar (Calicut) in April 2015 made a strong presence all along the coast by landing more than 200 t in ring seine and trawl landings during August-November months.

Crustaceans: Total penaeid prawns recorded during 2016 was 31127 t with the inshore prawns forming 29193 t. *Metapenaeus dobsoni* dominated with 50%, followed by *Parapenaeopsis stylifera* 25.2%, *Metapenaeus monoceros* 8.5%, *Fenneropenaeus indicus* 5.6%, *Metapenaeus affinis* 5.1%. Deepsea penaeid and non-penaeid prawns constituted about 1,665 t and 2,408 t in Kerala. The penaeid prawns accounted for 40.1% of which *Metapenaeopsis andamanensis* (30%) dominated followed by *Aristeus alcocki* (13.6%). While in deepsea non-penaeids, *Heterocarpus gibbosus* (20%) formed the major catch followed by *Plesionika quasigrandis* (13%) and *H. woodmasoni* (13%). Total lobster catch at Kerala was 82 t with *Thenus unimaculatus* being the dominant species (37.2 t), followed by *P. homarus* (7.4%) and *P. versicolor* (0.1%) among the inshore lobster catch and the deepsea lobster, *Puerulus sewelli* formed 10.5% of the catch at Sakthikulangara Fishing Harbour.

During the year, 2165 t of marine crabs was landed in Kerala recording a decrease of 29%. *Portunus sanguinolentus* (54.9%) dominated followed by *Charybdis feriatus* (27.1%), *P. pelagicus* (13.5%) and *Charybdis lucifera* (1.9%). There was considerable decrease in the landings of *C. lucifera* and *C. natator* over the previous year. *Charybdis smithii* and *Charybdis annulata* were recorded exclusively from Kollam and *Podophthalmus vigil* from Kozhikode and Ernakulam districts, which formed 0.9, 0.45 and 1.08% respectively.

Cephalopods: During 2012-16 the total cephalopod catch increased by a little more than 43000 to 207745 t. The average annual catch was also higher by 8000 t at 41549 t registering a 26.5% increase in production. The steep increase in catches in 2014 was principally due to a large spawning congregation of squids which happened during the post-monsoon period of 2013. This resulted in an extraordinarily large squid cohort in 2014. The increase in total production of cephalopods was not comensurate with increase in effort. The major gear exploiting cephalopods was trawl (70-80%), while other artisanal gears such as beachseines, handjigs, lines and gillnets were in use particularly in the southern district of Thriruvananthapuram. During 2012-16, Cephalopods showed maximum abundance in fishing grounds during the post-monsoon months of August, September and October with catch rates exceeding 15 kg h^{-1}. However during this period, inter-annual differences in abundance were also large considering the magnitude of the standard deviation. Interestingly, this is also the peak breeding period for both cuttlefishes and squids, and therefore, there exists great danger of recruitment overfishing. Present status of the important stock of cephalopods of Kerala was assessed. Of the 11 cephalopod stocks studied, *S. pharaonis*, *U. (P.) duvaucelii* and *Sepiella inermis*

are abundant, one stock is less abundant and seven stocks are declining. Among squids, the main species exploited was *U. (P.) duvaucelii* followed by *U. (P.) edulis*, *U. (P.) singhalensis* and *Sepioteuthis lessoniana*. Among cuttlefishes 5 species belonging to the genus *Sepia* were exploited and it was predominated by *S. pharaonis*. Among octopuses, *Amphioctopus negelectus* and *A. marginatus* were the most dominant followed by *Cistopus indicus* and *Octopus lobensis*. *S. pharaonis* showed a decline after 2014, and the catch of *U. (P.) duvaucelii* also showed a decline after the extraordinary peak during 2013-14. Both stocks have shown increase in recent years. *A. neglectus* catches remained steady after 2006, with increasing trend from 2011.

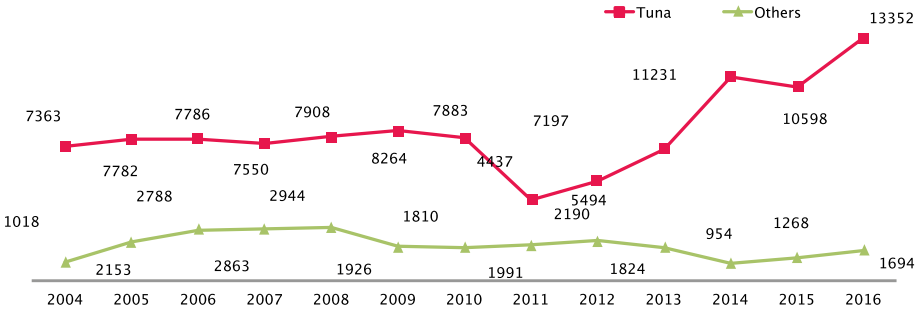
Price behavior analysis of marine fish at landing centre level indicated that the lowest prices were recorded for oilsardines (₹55 per kg) and the highest for seerfishes (₹391 per kg), black pomfrets (₹400 per kg) and lobsters (₹860 per kg). At retail level the highest prices were recorded for seerfishes (₹525 per kg), *P. indicus* (₹540 per kg), silver pomfrets (₹500 per kg) and lobsters (₹1100 per kg) and lowest prices were recorded for oilsardines (₹95 per kg) and threadfin breams (₹165 per kg). Fishermen's share in the consumer's rupee varied from 565 for lizardfishes to 89% for black pomfrets

Economic Loss: Juvenile fish component in the landings indicated that the estimated loss due to juvenile fishing of oilsardines was an average 48 crores during 2013-15 period.

Lakshadweep

Lakshadweep contributed 33.99% of the marine fish landings of which 35.73% of the total tuna, 21% of other fishes and octopus was from Minicoy, Agatti and Andrott islands. September to December was the most productive among the last 13 years (2004-2016). Landings of large pelagics including tunas, trevallies, rainbow runners and wahoo exhibited remarkable increase during the year. The total tuna production during the year increased by 20.63%, the production of other fishes and elasmobranchs also increased by 25.15%. The efforts expended in the pole and line fishery has shown a marginal increase of 2%, during the year. The surface skipjack shoals which were aggregating more around Androth, Kalpeni axis in recent years has almost spread out to entire Lakshadweep during the year under report. The availability of very high aggregations and exploitation of medium and large sized (15-30 kg sizes) yellowfin tunas near Kalpeni/Cheriyam and Androth islands during the last two years has declined considerably in 2016. This has seriously affected the total yellow fin landings. The species which supported the tuna fishery in 2015 and 2016 were *Katsuwonus pelamis* 83.36% and 77.2%, *Thunnus albacares* 13.15% and 18.1%, *Euthynnus affinis* 3.0% and 3.7%, *Auxis thazard* 0.4% and 0.7% and *Gymnosarda unicolor* 0.08% and 0.3%. The Kavaratti and Agatti fishermen resorted to traditional single pole and line method in order to exploit the highly preferred skipjack tunas to the yellowfin tunas. Price of "*mass*" crashed from ₹500-600 per kg in 2015 to ₹150-450 per kg in 2016 for the good quality ones. A good positive development achieved was the direct export of mass, bypassing the middlemen by the Lakshadweep Co- operative Marketing Federation.

Trend in the landings of Lakshadweep tuna & other fishes (in tonnes) 2004-16



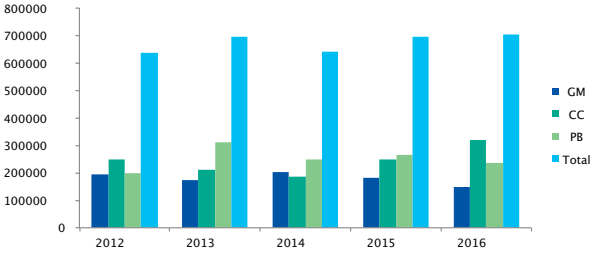
Deep sea prawns landing at Kasimedu

Tamil Nadu and Puducherry

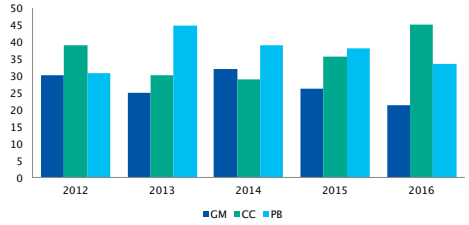
Research Project: FISHCMFRISIL201200800008

The total fish production in Tamil Nadu during 2012-2016 varied from 6.3 lakh t to 7 lakh t with an average of 6.7 lakh t.

The catch in 2016 increased by 1.5% compared to 2015. But the region-wise catch showed an increase only in Coromandel Coast (CC) whereas the catch decreased both in Gulf of Mannar (GM) and Palk Bay Coast (PB). The catch in Coromandel decreased from 2.5 lakh t in 2012 to 1.86 lakh t in 2014 and then increased to 3.2 lakh t in 2016. Catch in Gulf of Mannar plummeted to 1.5 lakh t in 2016 from 2.05 lakh t in 2014. In Palk Bay also, the catch decreased to 2.4 lakh t in 2016 from 3.1 lakh t in 2013. The percentage contribution of catch

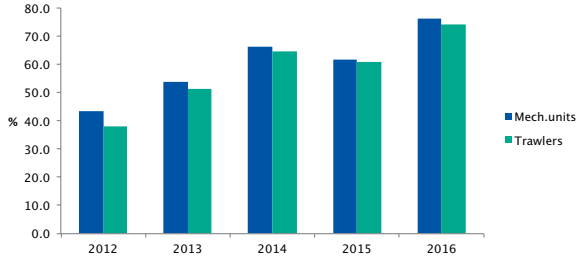


Total catch in Tamil Nadu during 2012-2016

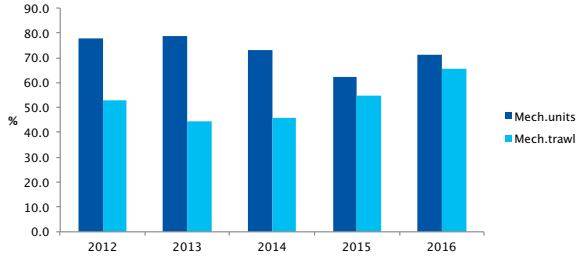


Percentage contribution of catch in different regions

to the total catch in Tamil Nadu showed that PB accounted for the highest till 2015 followed by CC but in 2016, 46% of the total catch in Tamil Nadu was by CC followed by PB (33.6%) and GM (21.2%). The total catch in mechanised units of the GM increased from 43.5% in 2012 to 76.1% in 2016 of which the catch in the mechanised trawlers varied from 38.2 to 74.1% during the same period. In CC, the total catch in mechanised units varied from 62.4 to 78.9% during 2012-16. The contribution by mechanised trawlers was 53% in 2012 but it decreased to 44.6% and thereafter showed a continuous increase registering 65.7% in 2016. The catch by mechanised ringseines during 2012 to 2014 varied from 20.3 to 27.2% but afterwards became insignificant. Unlike the other two regions, in Palk Bay, MTN almost fully dominated relegating other gears into minor players. Here the contribution by mechanised trawlers varied from 85 to 88.2%. In PB, demersal groups dominated only in 2012 but after that pelagic groups had clear domination varying from 52 to 60%. Another point was gradual decrease in percentage contribution of crustaceans and cephalopods from 2012. In CC, pelagic resources dominated in all the years. Crustacean and cephalopod catch showed marked improvement from 2012. The crustacean percentage increased from 5.5 in 2012 to 13.6% in 2016. Cephalopods also increased from 1.9 to 10.7% during the same period.

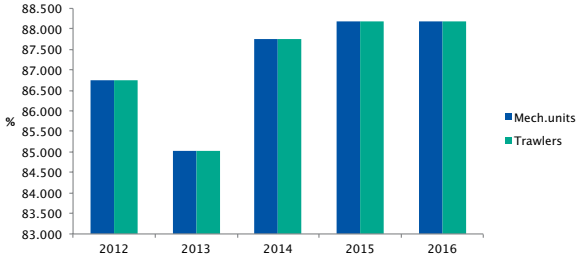


Percentage contribution of mechanised units in the total catch in GM

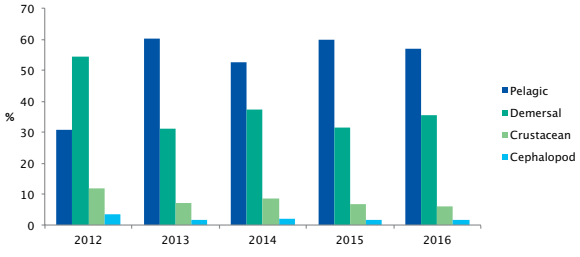


Percentage contribution of mechanised units in the total catch in CC

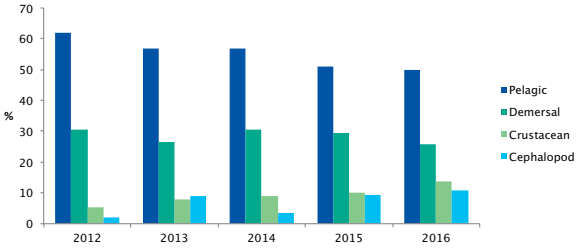
In GM, pelagic groups dominated in all the years except in 2014 when the demersal resources dominated. Crustaceans showed slight improvement from 1.1 in 2013 to 3.9% in 2016. But cephalopods showed marked improvement from 2.7 in 2014 to 12.3% in 2016. The resources which formed more than 5% of the total catch at least once during 2012-16 were very limited.



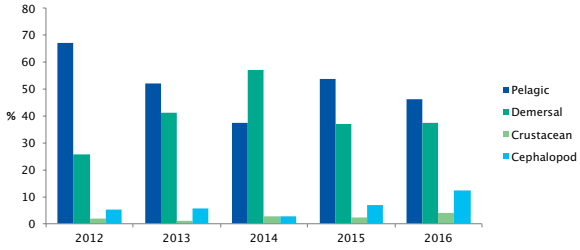
Percentage contribution of mechanised units in the total catch in PB



Percentage contribution of different groups in PB



Percentage contribution of different groups in CC



Percentage contribution of different groups in GM

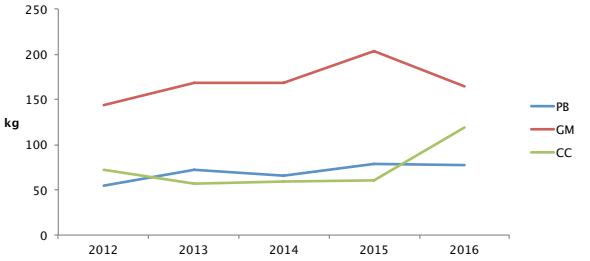
In CC, oilsardine, other sardines, carangids, ribbonfish, Indian mackerel and silverbellies dominated indicating the significance of small pelagics and small demersal resources in the marine landings besides penaeid prawns and cephalopods. Only other sardines and carangids were more than 5% of the catch in all the years. Oilsardine formed 14.5% in 2012 but thereafter, it dwindled in 2013 and 2014 then increased to 12.7% in 2015 and 7.9% in 2016. In GM, among pelagic resources, the same groups dominated as in Coromandel. However, among demersal groups, in addition to silverbellies, pigfacebreams formed a dominant resource. Other dominant item among shellfishes was cephalopod. Though lesser sardines have been a dominant resource in PB, oilsardine became a dominant resource since 2013. The other two resources were silverbellies and penaeid prawns.

The catch per hour in single day mechanised trawlers in 2016 was 118.7 kg registering an increase of 96.5% over the preceding year in CC. The CPH varied between 56.8 and 72.2 kg during 2012-2014. In GM, the CPH varied between 143.6 and 203.4 kg during 2012-2016. Here during 2016 the CPH showed a decrease of 19.5% when compared to previous year. In PB, the CPH in general was below 80 kg in all the years and showed a slight decline of 1.7% over the preceding year.

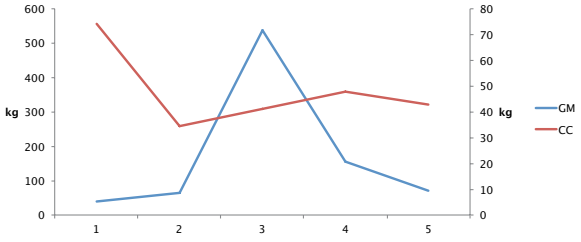
Dominant resources (%) in different regions

CC					
Resource	2012	2013	2014	2015	2016
Oilsardine	14.5	2.4	3.4	12.7	7.9
Other sardines	16.3	15.8	16.9	8.1	5.1
Ribbonfishes	6.2	1.5	1.1	1.9	4.6
Carangids	5.8	11.5	10.5	6.9	6.8
Indian mackerel	5.4	4.6	6.8	5.5	8.9
Silverbellies	10.7	6.5	7.2	4.7	3.8
Penaeid prawns	3.5	5.6	7	6.4	6.7
Cephalopods	1.6	9	3.6	9.4	10.7
GM					
Resource	2012	2013	2014	2015	2016
Oilsardine	16	0.8	1	2.2	1.4
Other sardines	10	23	13	17	11.7
Ribbonfishes	8.4	0.6	0.5	1.8	1.3
Carangids	6	11.6	7.3	17.1	8.3
Indian mackerel	5.3	3.2	4.1	3.8	2.7
Pig-face breams	4.7	2.9	3.9	7.6	3.6
Silverbellies	6.9	8.5	4.7	5.6	5.4
Cephalopod	5	5.6	2.7	6.8	12.5
PB					
Resource	2012	2013	2014	2015	2016
Oilsardine	2.2	40	9.5	19	20.4
Other sardines	15	8.6	28.6	25	25.4
Silverbellies	37.3	16	23.4	19.7	24.7
Penaeid prawns	6	4.1	5.1	4.1	3

The CPH in multiday trawlers registered a progressive dwindling in CC. It decreased from 74.1 kg in 2012 to 42.8 kg in 2016. In GM, the variation in CPH was very high between years. From 37.8 kg in 2012, it went up to 537.6 kg in 2014 and decreased to 155.4 kg in the succeeding year. It further decreased to 71.7 kg in 2016.



Catch per hour (CPH) in mechanised single day trawlers



Catch per hour (CPH) in mechanised multiday trawlers

The catch per unit effort (CPUE) in multiday gillnetters in GM showed continuous increase till 2015 and then showed a drastic reduction in 2016. The CPUE increased from 608 kg in 2012 to 129 kg in 2015 and drastically reduced to 336 kg in 2016. In CC, the CPUE showed marked improvement. It increased from 464 kg in 2012 to 13409 kg in 2016. This is partly due to the increased duration of fishing days per trip and also the increased storage capacity of the boats.

The CPUE in outboard motor operated gillnets (OBGN) in GM varied between 57 and 75 kg. It dwindled to 57 kg in 2016 from 75.4 kg in the preceding year. In CC, the CPUE was below 50 kg in the first two years and in the succeeding three years it was above 50 kg. In PB, the CPUE was between 28 and 43 kg and it did not show any pattern of decrease or increase.

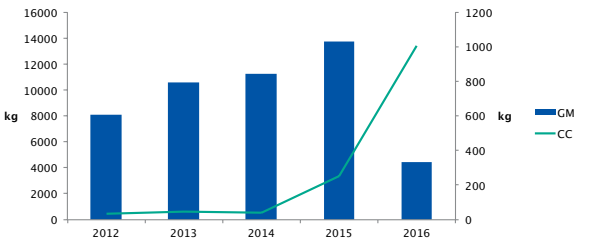
The CPUE in outboard operated hooks and line (OBHL) was better in GM and CC. In GM, it was between 45 and 299 kg and in CC, it was between 47 and 76 kg. In PB, the CPUE was below 15 kg in all the years and it registered as low as 2 kg in 2015.

The catch in Puducherry increased from 56262 t in 2012 to 79148 t in 2015. But in 2016, it plummeted to 45190 t showing a decrease of 43%.

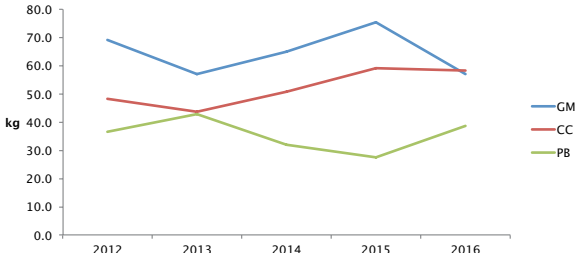
In 2015, almost 86% of the total catch was contributed by MDTN whereas in 2016, its contribution declined to 62% and that of MTN increased to 20% in 2016 from 2.5% in 2015.

Among the different resources which formed the fishery in 2015 and 2016, penaeid prawns and goatfish substantially increased in 2016 compared to 2015. But the notable development was the decrease of other sardines which decreased from 7.8 to just 0.9% in 2016.

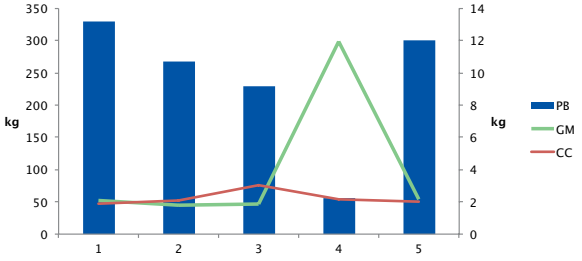
The mean size of most of the fishes were either close to or above the size at first maturity except in the case of larger species such as *T. albacares* and *S. commerson*. The targeted



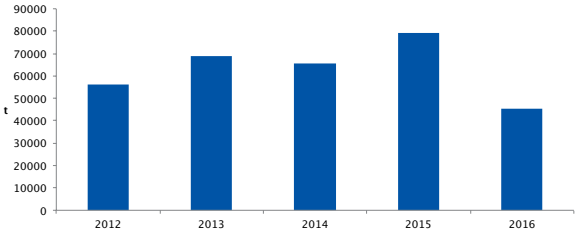
Catch per unit effort in mechanised multiday gillnetters



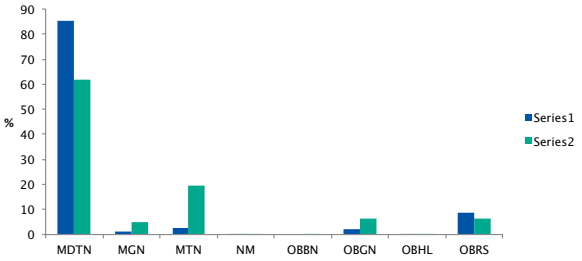
Catch per unit effort in outboard motor operated gillnetters



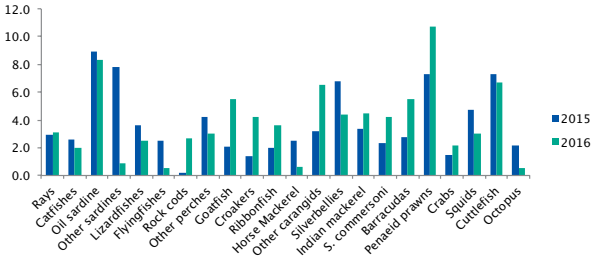
Catch per unit effort in outboard motor operated hook and line



Total catch in Puducherry during 2012-2016



Contribution of catch by different gears in Puducherry



Percentage composition of different resources in the total catch in Puducherry

Mean size (cm) of dominant pelagic, demersal and cephalopod resources from Tuticorin

Species	2012	2013	2014	2015	2016
K. pelamis	53.3	50.4	50.7	49.9	
T. albacares	69.4	75.3	75.1	67.8	
E. affinis	43.2	46.2	50.2	45.7	
A. thazard	36.7	36	37	31	
A. rochei	26.2	26.2	27	25.5	
S. orietalis	41.2	44.5	0	41.8	
S. commerson	86.8	79.6	68.9	86.6	
A. solandri	109	113	111	110.2	
C. hippurus	165.8	73.6	76	68.5	
R. kanagurta	23.9	22.7	22.8	21.9	
S. gibbosa	14.1	13.7	14.4	14.2	
S. longiceps	0	0	16.4	16.5	
S. fimbriata	0	0	13	136	
A. sirm	0	0	17.2	14.2	
S. indicus	12.5	12.5	13.1	12.4	
I. platyperus	165.8	179.6	144	132.9	
I. indica	235.7	247	222	235	
X. gladius	113.8	117	120	113.2	
P. indicus	0	0	0	25.2	21.7
L. lentjan	0	0	24.3	24.2	23.3
E. malabaricus	0	0	0	54.1	52.4
G. minuta	0	0	10.3	11.3	9.8
E. lineolatus	0	0	0	11.4	11.5
N. delagogue	0	0	23.5	19.5	20.2
S. prabhahari	11.3	10.5	11.3	9.1	9
U. (P.) singhalensis	0	0	0	11.6	13.3
U. (P.) duvaucelii	15.7	16.4	16.5	13.5	11.7
S. lessoniana	18.6	18.5	19	17.8	14.9
Sepia pharaonis	23.5	24.2	23.6	24.2	22.9

Mean size (mm) of prawns from Tuticorin

Species	Male	Female	Pooled
P. semisulcatus	138	159	148
P. indicus	134	142	138
P. latisulcatus	145	165	155
P. penicillatus	0	155	155
P. merguiensis	168	199	196
P. monodon	188	205	200
P. canaliculatus	138	0	138
M. moyebi	71	85	80
M. dobsoni	81	91	88
M. monoceros	93	118	108
M. affinis	83	133	100
P. uncta	77	106	100
P. maxillipedo	66	69	68
P. acclivirostris	58	58	58
P. stylifera	66	83	74
P. sculptilis	63	0	63
M. stridulans	60	65	63
M. mogiensis	58	60	59
T. curvirostris	58	60	59
T. granulosus	52	68	66
T. sedili	42	59	57
M. elegans	88	103	98
Alpheus rapacida	0	0	63
Aristeus alcocki	81	128	130
P. spinipes	0	0	84
P. martia	73	81	75
H. gibbosus	0	0	88
H. woodmasonii	0	0	82
S. hextii	96	98	97
S. choprai	79	76	77
S. koelbeli	79	85	83
S. crassicornis	0	66	66
P. longipes	68	85	84
P. jerry	86	80	84
P. fissuroides	76	87	90
P. investigatoris	88	84	85
P. retacuta	88	76	83
M. andamanensis	82	83	82
M. coniger	68	67	68
N. tenuispines	0	0	63
E. ensirostris	0	56	56

Mean size (mm) of dominant resources from Mandapam

Species	2012	2013	2016
S. albella	120.2	118.8	120
S. gibbosa	131.9	124.2	127
R. kanagurta	229.6	226	220
A. mate	0	0	250
S. leptolepis	0	0	110
S. obtusata	0	0	310
D. russelii	0	0	107
E. jonesi	82.2	80.4	106.3
G. minuta	0	0	114.8
K. daura	0	0	122
K. dussumieri	95.5	92.5	111
N. mannusella	0	0	107.3
N. maculata	158	151.5	163
U. tragula	139.5	138.1	0
U. sundaicus	117.8	117.5	0
P. macrophthalmus	123.1	137.8	0

Mean size (mm) of dominant pelagic, demersal and cephalopod resources from Chennai

Species	2012	2013	2014	2015	2016
S. indicus	109	118.9	123.6	120.2	120.1
R. kanagurta	215.9	208.8	207.9	217	214.7
R. faughni	0	0	208.4	175.8	208.9
S. gibbosa	121.2	146	128.1	127.7	113.4
S. longiceps	167.2	157.7	168	159.8	127.8
T. lepturus	482.5	488.9	503.9	517.2	490.2
K. pelamis	54.2	57.1	55.7	58.9	59.7
T. albacares	59.5	79.2	78.9	80.9	67
E. affinis	33.4	36.7	37.9	37.3	44.2
S. commerson	53.7	47.9	40.4	37.6	37.3
S. guttatus	45.8	37.1	39.3	33.8	29.8
S. tumbil	262.4	270	282	276.4	
S. undosquamis	0	0	179.1	193.8	
S. myops	187	181.4	179.9	200.8	
S. micropectoralis	0	0	0	298	
N. japonicus	164.5	172	152.1	153.4	
N. randalli	131	124.5	140.8	135	
N. bipunctatus	154.5	143.3	154	162.7	

fishery for *S. commerson* using large meshed drift gillnet of size 130-140 mm mostly brings larger size groups. The juveniles are mainly landed by trawlers especially during June-August and also by smaller meshed drift gillnet of 65-90 mm. In both these gears, it is landed as bycatch. Of these, 51% were found to be year round spawners. In 10.2%, the spawning was found in all the quarters except second, 6.1% each in IV and II-IV quarter, 4.1% each in first, second, first and second and third and fourth quarter and 2% each in first to third and first to second and fourth quarter.

Of the seven pelagic resources, for five resources both MSY and MSE were found at F-factors above 1 indicating scope for further exploitation. But the percentage of spawning stock biomass (SSB) with respect to the virgin spawning stock biomass (SSB0) at MSY and MSE level in some of the resources are below 20%. In the spatial stock status study of prawns and crabs, MSY is

The spawning season of major species from different areas in Tamil Nadu

	Species	Spawning months	Major spawning	Minor spawning
Tuticorin	*R.kanagurta*	Year round	January-July	October-December
	S. gibbosa	Year round		
	A. srm	May-June		
	A. clupeoides	March-August		
	S. indicus	February-November		
	E. affinis	January-August		
	T. albacares	Mar-April& Jul-Aug		
	K. pelamis	Year round	January-June	October-December
	A. rochei	April-November		
	T. crocodilus	October-December		
	T. melanota	October-December		
	A. hians	October-December		
	M. maculata	July-Aug		
	L. lentjan	Year round	Jun-Aug	Apr-Jun
	P. indicus	May-Nov	Jul-Sep	
	N. bipunctatus	Jun-Mar	Jun-Oct	
	G. minuta	Year round	Mar-Apr&Nov-Dec	
	E. lineolatus	Year round	Mar-Apr&Nov-Dec	
	P. pelagicus	Year round	Dec	March & July
	P. sanguinolentus	Year round	February-July	
	C. natator	Year round	Jun-Aug	
	P. gladiator	Year round	August-October	
	P. indicus	Throughout	August–October	
	P. semisulcatus	Throughout	July-September	
	P. maxillipedo	Jan-Mar & July-November	March, August	
	P. latisulcatus	June- Dec	June-August & November	
	M. toloensis	June-November	September	
	M. moyebi	June- February	Aug-Sepr, Jun, Jan	
	M. dobsoni	January,July-November	July,September	
	M. hilarula	June-July	June	
	M. stridulans	June -December	Oct, June-July	
	M. mogiensis	July-November	Oct	
	M. andamanensis	January		
	M. coniger	February		
	H. gibbosus	October- March	November, March	
	P. quasigrandis	November-March	January-february	
	H. hextii	November -April	January-february	
	Sepia prabahari	Aug-Sep	Dec-Jan	
	U. (P.) singhalensis	Aug-Sep	Dec-Jan	
Mandapam	*A. mate*	Year round	July-September	
	R. kanagurta	Year round	July-September	March-May
	S. albella	Year round	Feb-Apr	July-Aug
	S. gibbosa	Year round	Feb-May	July-September
	S. obtusata	Year round	July-September	Dec-January
	S. leptolepis	Year round	February-April	July-September
	G. oyena	Year round	February-April	July-September
	S. aculeata	February-June		
	S. lessoniana	Januay-March	July-September	
Chennai	*S. tumbil*	Year round		
	S. undosquamis	Year round	October-December	
	S. myops	Year round		
	S. micropectoralis	Year round	October-December	
	N. japonicus	Year round	October-December	
	N. randalli	Year round	June, November	

reached at the present level in *P. semisulcatus* and *P. indicus* and the fishing pressure can be increased by 40% to obtain the MSY. *P. sanguinolentus* is found to be overexploited whereas in *P. pelagicus*, the exploitation by indigenous trawl is above MSY level and the exploitation by gillnets are below MSY level. In *P. gladiator*, the present fishing is below the MSY level.

Population characteristics of dominant pelagic, demersal and cephalopod resources from Tuticorin

	L_∞	k	t_0	M	F	Z	E
T. albacares	211.1 cm	0.27	-0.056	0.447	1.403	1.85	0.76
K. pelamis	90.3 cm	0.5	0	0.848	1.25	2.1	0.6
E. affinis	81.92cm	0.56	-0.0317	0.94	2.68	3.62	0.74
S. commerson	184.8 cm	0.34	0	0.54	1.39	1.93	0.72
S. indicus	16.8 cm	1.5	0	2.783	2.81	5.59	0.5
R. kanagurta	31.6 cm	1.2	0	2.02	2.27	4.29	0.5
S. gibbosa	21.7 cm	1.16	0	2.19	6.6	8.79	0.75
P. indicus	378.5 mm	0.79	0	1.43	3.98	5.36	0.74
L. lentjan	514 mm	0.51	0	0.99	3.73	4.72	0.79
E. malabaricus	137 cm	0.4	0	0.64	0.94	1.58	0.59
G. minuta	163.2 mm	1.26	0	2.46	1.15	3.618	0.32
S. prabhahari	18.8 cm	0.99	0	2.05	3	5.1	0.58
U. (P.) singhalensis	31.75 cm	0.5	0	1.22	2	3.14	0.63
U. (P.) duvauceli	31.4 cm	0.9	0	1.67	2.38	4.05	0.58
S. lessoniana	38.2 cm	1.25	0	1.96	1.81	3.77	0.48
Sepia pharaonis	48.41 cm	1.1	0	1.68	3.13	4.82	0.64

Seerfish landing at Tuticorin

Population characteristics of dominant crab resources from Tuticorin

									Generation		Trawl		Artisanal	
		L_∞	K	M	L_{opt}	L_m	time	L_c	Z	L_{max}	L_c	Z	L_{max}
P. pelagicus	Male	195	1.6	2.5	128	93	70	4	185				
	Female	210	1.3	2	138	118	0.8	81	3.9	200			
P. sanguinolentus	Male	242	1.6	2.5	159	77	75	10	170	105	16	215	
	Female	222	1.3	1.9	148	105	0.8	88	8	160	97	9.6	215
C. natator	Male	182	1.1	1.7	120	56	61	5.4	135	70	6.6	175	
	Female	135	1.3	2	89	89	0.8	66	8.2	115	69	7.7	130
P. gladiator	Male	115	1.1	1.6	77	54	66	7.9	120	74	4.6	105	
	Female	123	0.9	1.4	81	60	1.2	46	3.5	120	64	7.4	95

Population characteristics of dominant prawn resources from Tuticorin

		L_∞	K	M	L_{opt}	L_m	Generation time	L_c	Z	L_{max}
P. semisulcatus	Male	227	1.6	2.5	149			128	9	215
	Female	273	1.5	2.3	181	135	9	144	7.5	260
P. indicus	Male	212	1.35	1.97	143			129	4.2	205
	Female	244	1.45	2.15	163	130	9	144	8.3	235
P. latisulcatus	Male	203	1.6	1.8	149			154	4.6	200
	Female	225	1.9	2.3	160	111	9.1	139	2.4	220
P. maxillipedo	Male	116	1.6	2.5	76			66	7.4	110
	Female	129	1.7	2.9	82	82	7	61	3.6	125

Population characteristics of dominant demersal and cephalopod resources from Chennai

	L_∞ (mm)	k	t_o	L_m	M	F	Z	E	U
S. tumbil	574.5	0.581	0.019	274	0.55	1.06	1.61	0.66	0.53
S. undosquamis	396	0.61	-0.221	238	0.92	0.88	2.04	0.56	0.49
S. myops	180								
S. micropectoralis	220								
N. japonicus	304	0.76	-0.007	133	1.66	0.92	2.58	0.36	0.33
N. randalli	232	0.86	-0.0188	120	1.73	1.64	3.37	0.49	0.47
N. bipuntatus	267	0.75	-0.022	125	1.14	0.76	1.9	0.4	0.34
U. (P.) duvaucelii	320	0.85	0	80	1.62	1.62	4.52	0.63	
Sepiella inermis	122.5	2.25	0	60	4.01	4.73	8.74	0.54	

Population characteristics of dominant pelagic and cephalopod resources from Mandapam

Species	L_m (mm)	L_∞ (mm)	Kyr^{-1}	t_o	L_{mean}	M	Z
S. albella	120	194.08	1.01	-0.0073	120	1.12	4.22
S. gibbosa	131	210.06	1.82	-0.0062	127	1.96	8.85
R. kanagurta	219	312.2	1.76	-0.0723	220	1.32	6.9
A. mate	231	290.02	1.06	-0.0126	250	1.34	3.98
S. leptolepis	130	202.6	1.3	-0.0014	110	1.12	5.04
S. pharaonis	185	321	1.4	0.0036	185	1.29	3.6
S. aculeata	112	222	1.12	0.0054	105	1.98	4.86
S. lessoniana	139	292	0.83	-0.019	170	0.823	2.87
S. obtusata	290	478.09	0.96	-0.0002	310	1.47	3.02

Stock status of major pelagic resources exploited from Gulf of Mannar

	F-factor	Yield (t)	Biomass (t)	SSB (t)	% Biomass	% of SSB of SSB_0	Status
T. albacares	1	1437	1518	939	13	8.7	
	0.4	1767	3780	3057	33	28.4	MSY&MSE
S. commerson	1	2938	2331.3	1487.4	85.5	10.7	
	0.4	3426	4854	3941	33	28.3	MSY&MSE
K. pelamis	1	557	459	251	27.6	17.5	
	1.1	558	430	224	26	15.6	MSY&MSE
E. affinis	1	1325	1325	651	87.3	23	
	1.2	1332	1236	569	35	20	MSY
	1.3	1332	1200	535	34	19	MSE
R. kanagurta	1	4956.8	5490.4	3484.2	59.9	48.7	
	8	6657.6	2775.5	855.1	30.3	12	MSY
	3.3	6421	3672.6	1696.1	40.0	23.7	MSE
S. gibbosa	1	12819.1	6176.2	2859.6	52.3	26.1	
	2	13382.4	5117.9	1840.4	40.6	16.8	MSE
	5	13533.4	4111.7	944.9	22.6	8.6	MSY
S. indicus	1	4276.1	5156.2	2288.5	38.1	54.7	
	4	6649.9	3619.5	911.7	50.9	21.8	MSE
	9	7538.5	2818.4	331.3	39.6	7.9	MSY

Stock status major crab and prawn resources exploited from Gulf of Mannar

		F-factor		%SSB		
Species	Gear	MSY	MSE	Present	MSY	MSE
P. pelagicus	Ind.trawl	0.6	0.4	7	15	25
	Est.gill net	1	0.8	14	14	18
	Mar.gill net	1.4	0.8	13	18	27
P. sanguinolentus	Mech.trawl	0.6	0.4	9	18	29
	Artisanal	0.6	0.4	9	15	24
C. natator	Mech.trawl	0.6	0.4	13	22	31
	Artisanal	1	0.8	15	15	20
P. gladiator	Mech.trawl	3.4	2	40	21	27
	Artisanal	3.2	2	39	24	29
P. semisulcatus	Trawl	Present	0.8	14	18	
P. indicus	Trawl	1.4	Present	24	33	

Tuna landing at Tuticorin

Potential yield and maximum sustainable fleet size

The potential yields for the three regions are found higher than the average catch in all the three regions. In Coromandel, the demersal catch is 56.5% of potential catch, small pelagic 75%, large pelagic 73.9%, crustacean 74.1%, cephalopod 57.2% and the total 67.5%. In Palk Bay, crustacean and cephalopod catches are 87.5% and 85.3% of potential catch but small pelagics is only 53.5% of the potential catch. In Gulf of Mannar, large pelagics and cephalopods are 69.3 and 67.4% of their respective potential catch but in other resources, the catches are over 70% of their potential catch.

Potential yield and average catch from different regions of Tamil Nadu

	Coromandel			Palk Bay			Gulf of Mannar		
Group	Potential	Average	% of potential	potential	average	% of potential	potential	average	% of potential
Catch(t)	Catch(t)	catch	Catch(t)	Catch(t)	catch	Catch(t)	Catch(t)	catch	
Demersal	103407	58400	56.5	92010	63720	69.3	75014	64846	86.4
Small pelagic	134234	100857	75.1	139316	74522	53.5	112392	79426	70.7
Large pelagic	20795	15376	73.9	4604	3224	70	18319	12697	69.3
Crustacean	16601	12297	74.1	23461	20528	87.5	6053	4378	72.3
Cephalopod	11675	6674	57.2	5255	4480	85.3	11726	7907	67.4
Total	286712	193604	67.5	264646	166474	62.9	223504	169254	75.7

Maximum sustainable fleet size (MSFS) and existing fleet size

Coromandel			Palk Bay			Gulf of Mannar		
Different crafts	Existing fleet size	MSFS	Different crafts	Existing size	MSFS	Different crafts	Existing fleet size	Maximum sustainable fleet size
Mechanised trawl	2139	1698	Mechanised trawl	2650	1220	Mechanised trawl	908	685
Mechanised ring seine	249	88	(If 50% do cross border fishing)		610	Mechanised hook & Line	380	226
Mechanised drift gill net	284	420	Out board gill net	2571	3626	Mechanised drift gill net	N.A	153
Out board gill net	12807	8880	Other OBM	N.A	250	Out board gill net	9482	5996
OBHL	N.A	279	Outboard hook & line	N.A	595	Outboard hook & line	N.A	988
OBRS	N.A	87	Outboard ring net	57	35	Outboard ring net	N.A	155
OBTN	N.A	59	Outboard trawl net	N.A	648	Outboard trawl net	N.A	38

Kasimedu landing centre

a. Oil sardine landing at Cuddalore
b. Pomfrets at Jagathapattinam
c. Billfish landing at Kasimedu

Coromandel

The mechanised trawlers are 26% in excess of the MSFS and that of OBGN is 44% in excess. Mechanised ringseine is also very much in excess of the MSFS. But the mechanised drift gillnet targeting oceanic resources are 32% less than the MSFS. Ringseines are operated after ascertaining the abundance of resource. Considering the operational expense, blind operation is very rare. So there are more non-fishing days.

Palk Bay

The existing mechanised trawlers are found to be in excess of 117% of the MSFS if we ignore the alleged cross border fishing. A survey of the fishermen from different areas of Palk Bay revealed that the percentage of crossborder fishing range from 40 to 95%. The maximum crossborder fishing is by the boats from Rameswaram because of the geographical peculiarity. Their only option is to move towards north and because of their proximity to IMBL, there is every likelihood of crossing it. So there is both intentional and unintentional crossing. Therefore on a moderate assumption that there is 50% crossborder fishing considering all the boats from Palk Bay, the existing boats are in excess of 334% of MSFS. However, the OBGN are 29% less than the MSFS.

Gulf of Mannar

The mechanised trawlers are 33% in excess of the MSFS. MHL and OBGN are also in excess of 68% and 58% respectively of the MSFS.

Andhra Pradesh

Research Project: FISHCMFRISIL201201100011

The total marine landing of Andhra Pradesh ranged from 3.04 lakh t in 2012 to 2.03 lakh t in 2016. The highest landing during the period was in 2014 at 3.4 lakh t. Pelagic species were the dominant resource group during 2012-2016. The contribution of the major resource groups was pelagic 62.28%, demersal 23.12%, crustacean 11.93% and molluscan 1.16%. Dominant pelagic resources were lesser sardines contributing 12.9% to total marine landings over the period followed by Indian mackerel (12.0%) and ribbonfish (5.9%). The dominant demersal resource was croakers (4.1%) and the dominant crustacean resource the penaeid prawns (8.9%). Cuttlefish was the dominant molluscan resource (0.7%). The dominant gear during 2012-2016 was mechanised trawlnet with

trawlers landing 41.61% of marine landings. This was followed by seinenets (including ringseines) contributing 19.83%, gillnets 15.87% and artisanal gears 13.69%. The catch rate of mechanised trawls fell from 29.3 kg h^{-1} in 2012 to 19.58 kg h^{-1} in 2016. The highest catch rate of trawls was in 2014 at 34.13 kg h^{-1} and the average for the time period was 27 kg h^{-1}.

Among other gears, the highest CPUE was for the seines (including ringseines) at 400 kg $unit^{-1}$. This was followed by gillnets at 51 kg $unit^{-1}$ and hooks and line at 49 kg $unit^{-1}$.

The major pelagic resources of the state were lesser sardines (*Sardinella* spp.), oilsardine *Sardinella longiceps*, *Thryssa* spp., *Stolephorus* spp., *Rastrelliger kanagurta*, horse mackerel, scads, leatherjackets, *Scomberomorus commerson*, *Scomberomorus guttatus*, *Euthynnus affinis*, *Katsuwonus pelamis*, *Thunnus albacares*, *Auxis thazard*, billfishes and barracudas.

Major demersal resources were threadfin breams (*Nemipterus japonicus*, *N. randalli, N. bipunctatus, N. nematophorus)* , croakers (*Otolithes ruber*, *Pennahia anea*, *Johnius carutta*, *Nibea maculata)*, pomfrets (*Pampus argenteus*, *Pampus chinensis*), silverbellies (*Photopectoralis bindus*, *Eubleekeria splendens*, *Gazza minuta*) and goatfish (*Upeneus indicus* , *Upeneus supravittatus)*.

The major crustacean resources were prawns (*Solenocera crassicornis*, *Metapenaeus monoceros*, *Metapenaeus dobsoni*, *Fenneropenaeus indicus*, *Penaeus monodon*) and crabs (*Portunus sanguinolentus*, *Portunus pelagicus)*.

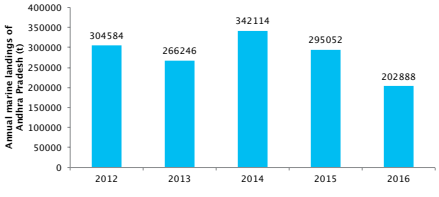
Major molluscan resources were cuttlefish (*Sepia pharoanis*, *S. aculeata*, *S. brevimana*, *S. prashadi*, *Sepiella inermis*), squid [*U.* (*P.*) *duvaucelii, Sepioteuthis lessoniana, Uroteuthis* (*Photololigo*) *edulis, U.* (*P.*) *sibogae, Loliolus* (*Loliolus*) *hardwickei, Loliolus* (*Nipponololigo*) *uyii*] and octopus (*Amphioctopus aegina*, *Cistopus* sp., *Amphioctopus neglectus)*.

Rapid stock assessment

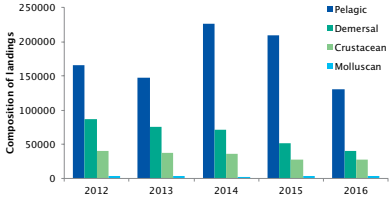
Over 2012 to 2016, the status of the fish stocks along Andhra Pradesh coast worsened, as estimated by the RSA methodology. In 2012, 36% of the stocks were in the "Abundant" category which decreased to 15% by 2016. The percentage of stocks in the "Less Abundant" and "Slow Declining" categories increased to 36% and 30% from 30% and 18% respectively. The percentage of "Collapsed" stocks increased from 7 to 10% from 2012 to 2016.

Change in stock status of major marine fishery resources of Andhra Pradesh over 2012-2016

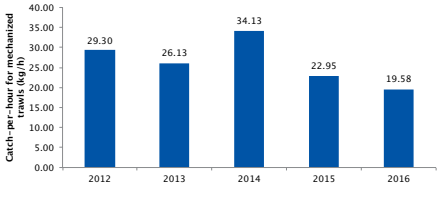
Of the 62 stocks monitored, only 5 stocks showed an improvement in their status over 2012-2016. These were oilsardine, other shads, *Thryssa* spp., *Scomberomorus guttatus* and soles. All the other stocks went from a less severe category to a more severe category over 2012-2016. *Setipinna* sp. and pigface breams moved from "Declining" category to "Collapsed" category. Other "Collapsed" stocks included Hilsa shad, *Scomberomorus lineolatus*, *Acanthocybium* and *Bregamceros* sp. Twenty-one stocks maintained their status over the time period.



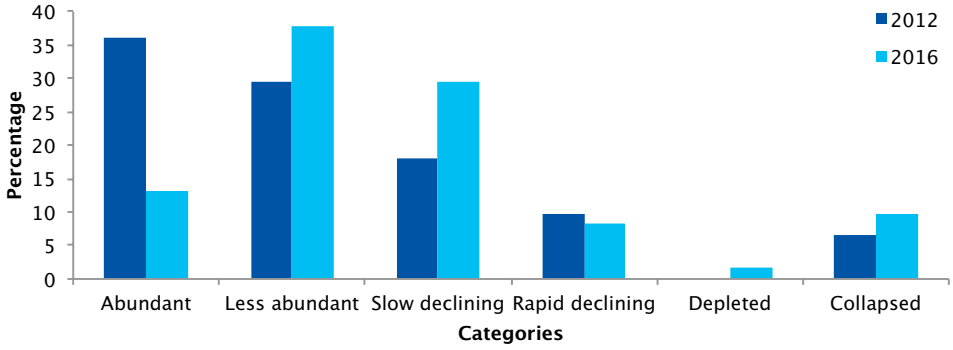
Annual marine landings of Andhra Pradesh (2012-2016)



Major resource group contribution to total landings of Andhra Pradesh (2012-2016)



Decreasing catch rates (kg h^{-1}) of mechanised trawlers of Andhra Pradesh (2012-2016)



Change in stock status of major marine fishery resources of Andhra Pradesh over 2012-2016

Biology of major species landed along Andhra Pradesh

Sardine: The length of oilsardine, *Sardinella longiceps* at Visakhapatnam ranged from 60 to 229 mm over 2012-2016. The annual sex ratio ranged from 1- 1.5 during this period. The annual mature percentage ranged from 4.3-28.4% and GSI ranged from 4.4-5.9. May–July is the peak breeding season of oilsardine. Average fecundity was 31200 with ova diameter varying from 0.38 mm to 0.54 mm.

Mackerel: The length of Indian mackerel, *Rastrelliger kanagurta* at Visakhapatnam ranged from 70 to 269 mm and annual sex ratio ranged from 1- 2.3 over 2012-2016. The annual mature percentage ranged from 5.6-32.7% and GSI from 3.1-5.5. March–September was the peak breeding month. Fecundity ranged from 137500-153505 with ova diameter varying from 0.19 to 1.02 mm.

Ribbonfish: *Trichiurus lepturus* was the sole species with size ranging from 320 to 1119 mm, having mean length of 631.4 mm. Highest mean length of 882.3 mm was observed in June and lowest of 507.1 mm in February. Annual sex ratio was 4.1. Males dominated the catches during February, June, September and October, whereas females dominated in rest of the months. Mature females were encountered in high numbers in June, September–November and again in February. Highest GSI of 8.1% was observed in December. The high IRI values of sardines, *Stolephorus*, mackerel, scad and digested fish imply that they were the principal food constituents of *Trichiurus lepturus*. Near to half of the fishes had their stomachs either empty or had trace amounts of food material in it. Feeding intensity was higher during January – February and August.

Tuna: The length of skipjack tuna, *Katsuwonus pelamis* at Visakhapatnam ranged from 280 to 659 mm with an annual mean of 500.1 mm. The highest mean length of 552.2 mm was recorded in the month of October and the lowest mean length of 455 mm was recorded in February. Annual sex ratio was 2.7 with female domination in all months. Mature females were encountered in March and July. Average GSI was 1.6. Feeding intensity was higher during July to September. The high IRI values of cephalopod, mackerel, *Decapterus*, sardine, flying fish and other carangids imply them to be the principal food constituents. The length of yellowfin tuna, *Thunnus albacares* at Visakhapatnam ranged from 320 to 1679 mm with an annual mean of 656.7 mm. Maximum mean length of 5 mm was recorded in June and minimum mean length of 373.6 mm in March. Annual sex ratio was 3.5 with male domination in July and female domination in January and March. Mature females were encountered in July. Feeding intensity was higher in March and July. Cephalopods are their preferred prey, followed by *Selar* and other carangids.

Seerfish: The length of *Scomberomorus guttatus* at Visakhapatnam ranged from 220 to 559 mm with an annual mean of 362.5 mm. Highest mean length of 428 mm was recorded in March and lowest mean length of 310.2 mm in July. Annual sex ratio was

5.5 with female domination in all the months. Feeding intensity was high in January, February and August. *Stolephorus* and sardine were the principal food components encountered in their gut. For *Scomberomorus commerson*, the length varied between 240 to 1139 mm with annual mean of 504.8 mm. Highest mean length of 740.5 mm was recorded in July and lowest mean length of 327 mm in August. Annual sex ratio was 1.9. Males dominated the catches in January and females dominated from August–October. Mature females were observed in August. Feeding intensity was higher during January and September–October.

Barracuda: The length of *Sphyraena jello* at Visakhapatnam ranged from 140 to 779 mm with an annual mean of 380.2 mm. Highest mean length of 691.3 mm was recorded in June and lowest mean length of 253.7 mm in April. Annual sex ratio was 3.7 with male domination in April and October and female domination in rest of the months. Mature females were encountered in June and to a lesser extent in October. Average GSI % was 2.7. Feeding intensity was higher in February, March and June. The high IRI values of *Stolephorus*, sardine and myctophids imply them to be the principal food constituents.

Orange spotted grouper: *Epinephelus coioides* ranged from 159 to 1016 mm TL with weights ranging from 50 to 19.5 kg. The mean size was 441 mm. The diet components included fish, prawns and rarely squid.

Indian halibut: The size of the Indian halibut *Psettodes erumei* ranged from 165 to 605 mm with weights ranging from 73 to 3334 g. The mean size was 336 mm and sex ratio 1.4. Of the females observed, 60% were mature. Fish was the predominant diet component.

Threadfin breams: *Nemipterus randalli* ranged from 99 to 265 mm TL with weights ranging from 5 to 94 g. The mean size was 141 mm, sex ratio was 1.14 and 69.3% of female fish were mature. Fish and prawns were the main diet components.

Croakers: *Nibea maculata* ranged from 113 to 243 mm TL with weights ranging from 18 to 195 g. The mean size was 178 mm. Sex ratio was 1.2 and 70.7% of female fish were mature. Main diet components were fish, prawns and crabs.

Catfish: *Netuma thalassina* ranged from 116 to 995 mm TL with weights ranging from 27 to 6.89 kg. The mean size was 377 mm and mean weight was 841 g. Sex ratio was 1 indicating equal presence of male and female fish in the samples. Main diet components were fish, crab, stomatopods and prawns.

Flatheads: The length range of *Platycephalus indicus* was 134 to 582 mm with weight ranging from 16 to 1449 g. Mean length was 406 mm and weight 520 g. Sex ratio was 1.2 with 97% of females being mature. Predominant diet was fish, followed by cephalopods and *Acetes*

Indian pompano: The length (TL) range of *Trachinotus mookalee* was 278-876 mm with weights ranging from 289-9450 g. Mean length was 523 mm with mean weight being 2315 g. Sex ratio was 2.1 and 50% of the observed females were mature. Diet was dominated by gastropods and bivalves with some contribution from crabs.

Penaeid prawns: Total length of *Metapeneaus dobsoni* females was in the range 5.3-12.8 cm and that for males was 5.3-11.8 cm. Maximum observed weight per animal was 8 g for females and 7 g for males and sex ratio was nearly 1.

Crabs: The length range of *Portunus sanguinolentus* females was 7.3-20.3 cm and that for males was 6.3-20.8 cm. Maximum observed weight per animal was 145 g for females and 270 g for males. The sex ratio was 0.68.

Cuttlefish: The biology of *Sepia aculeata* and *Sepia pharaonis* was studied from 2012-2016. The Dorsal Mantle Length (DML) of *Sepia aculeata* ranged from 68 to 256 mm with a mean

a. Shark pups for sale at Visakhapatnam Fishing
b. A section of the trawl catch caught by RV Cadalmin I off Visakhapatnam Harbour

of 141.26 mm. Weight ranged from 44-1028 g with an average weight of 311.38 g. The sex ratio was 1.55. Juveniles contributed 6% to total landings of the species. Diet was mostly crustaceans like squilla, crabs and prawns and to some extent fishes like cardinal fishes, silverbellies, anchovies and threadfin breams. The DML of *Sepia pharaonis* ranged from 87 to 302 mm with a mean of 171.99 mm. Weight ranged from 74-1555 g with an average weight of 508.23 g. Sex ratio was 0.83. Juveniles contributed 3% to total landings of the species. Diet was mostly crustaceans like squilla, crabs and prawns and to some extent fishes like cardinal fishes, silverbellies, goatfishes, juveniles of snappers, threadfin breams and sometimes even squids.

Squid: The DML of *U. (P.) duvaucelii* ranged from 25 to 190 mm with a mean of 93.11 mm. Weight ranged from 9-165 g with an average weight of 39.11 g. The sex ratio was 0.95. Juveniles contributed 39% to total landings of the species. Diet was mostly crustaceans like prawns and to some extent fishes like cardinal fishes, silverbellies, anchovies, goatfishes and threadfin breams.

The marine environment along Andhra Pradesh

A compiled dataset for 5 years from April 2012 to March 2017 was created for different environment variables related to fisheries along Visakhapatnam coast. Seawater temperature reached maximum during the month of May and again during September. Temperature values ranged from minimum of 25.7°C during December to maximum of 30.43°C during May. Salinity reached maximum during April (34.14 ppt). Minimum was observed during October (27.74 ppt). Hydrogen ion concentration (pH) peaked during summer months (March- April value 8.14-8.19) and was lowest during September–November at 7.96. Dissolved oxygen (DO) was lowest during summer months (May) and highest during September-October. Nutrients like ammonia, phosphate and nitrate along with chlorophyll showed higher concentrations during periods of low salinity.

Socio-economic studies

A socio-economic survey of marine fishermen of Andhra Pradesh was carried out in 2016. All fishermen surveyed feel that the fish in the sea and the sea are owned by fishermen. The major constraints faced by fishermen was lack of labour, high fuel price, low first sale price, depletion of resources (low catch rates), too many boats and fishermen, lack of modern infrastructure and lack of proper fishery insurance products.

Growth and mortality parameters for major pelagic resources of Andhra Pradesh

Species	L_∞ (cm)	k	M	F	Z	E
Rastrelliger kanagurta	25.33	0.56	1.18	0.78	1.96	0.40
Sardinella longiceps	23.36	0.90	1.85	2.30	4.15	0.55
Trichiurus lepturus	108.44	0.24	0.54	0.66	1.20	0.55
Katsuwonus pelamis	65.66	0.50	0.83	0.78	1.61	0.48
Thunnus albacares	192.75	0.14	0.30	0.38	0.68	0.56
Scomberomorus guttatus	62.42	0.33	0.68	0.84	1.52	0.55
Scomberomorus commerson	126.56	0.18	0.26	0.34	0.60	0.57
Sphyraena jello	72.68	0.38	0.54	0.69	1.23	0.56

Growth and mortality parameters for major demersal resources of Andhra Pradesh

Species	L_∞ (cm)	k	M	F	Z	E
Nemipterus japonicus	29.87	0.42	1.01	0.57	1.58	0.36
Nemipterus randalli	28.0	0.20	0.64	1.84	2.54	0.74
Upeneus vittatus	22.7	0.32	0.92	0.6	1.52	0.40
Psettodes erumei	67.0	0.59	1.01	1.57	2.58	0.61
Nibea maculata	30.0	0.49	0.78	0.73	1.51	0.48
Otolithes ruber	43.0	0.18	0.53	0.32	0.85	0.38
Saurida undosquamis	42.0	0.24	0.64	0.80	1.44	0.56

Growth and mortality parameters for major crustacean and molluscan resources of Andhra Pradesh

Species	L_∞ (cm)	k	M	F	Z	E
Metapenaeus. dobsoni female	13.4	1.7	3.11	4.3	7.41	0.58
Metapenaeus dobsoni male	12.4	1.9	3.4	6.56	9.96	0.66
Portunus sanguinolentus female	21.0	1.56	2.59	8.99	11.58	0.77
Portunus sanguinolentus male	21.55	1.5	2.5	5.6	8.1	0.69
Sepia aculeata	28.35	1.15	1.99	8.33	10.32	0.81
Sepia pharaonis	35.6	1.1	1.81	3.65	5.46	0.67
Uroteuthis (Photololigo) duvaucelii	24.8	1.1	2.01	7.34	9.35	0.79

Multiplication factor of Fishing mortality for optimal fishing of major resources of Andhra Pradesh as estimated by the Thompson and Bell Model

Species	Multiplication factor	Status of fishing on resource
Sardinella longiceps	Beyond 2.9	Fishing less than optimum
Rastrelliger kanagurta	Beyond 2.9	Fishing less than optimum
Trichiurus lepturus	Beyond 2.9	Fishing less than optimum
Psettodes erumei	2.2	Fishing less than optimum
Nemipterus randalli	3.0	Fishing less than optimum
Nemipterus japonicus	1.8	Fishing less than optimum
Nibea maculata	1.2	Optimal fishing
Metapenaeus dobsoni female	0.4	Fishing beyond optimum
Metapenaeus dobsoni male	0.4	Fishing beyond optimum
Portunus. sanguinolentus female	0.4	Fishing beyond optimum
Portunus sanguinolentus male	0.4	Fishing beyond optimum
Sepia aculeata	0.4	Fishing beyond optimum
Sepia pharaonis	0.6	Fishing beyond optimum
Uroteuthis (Photololigo) duvaucelii	0.4	Fishing beyond optimum

Trawl fishery of the Northeast coast

Research Project: FISHCMFRISIL201203200032

Total production by trawlers during 2016 along the north-east coast of India was 2.43 lakh t an increase by 20.3% compared to 2.02 lakh t landed in 2015. The catch rate was 36.20 kg h^{-1}, while in 2015 it was 32.56 kg h^{-1}. Trawl landings in Andhra Pradesh was 0.78 lakh t forming 38.32% of the total marine landings. The overall catch rate was 19.58 kg h^{-1} for the state. The contribution by sona boats to the trawl landings was 99.32% and small mechanised trawlers 0.68%. Catch rate in sona boats was 19.51 kg h^{-1} and in small mechanised trawlers 38.41 kg h^{-1}. Trawl catches decreased by 5.13% in 2016 as also the catch rates. In Odisha, the trawl catch was 0.85 lakh t forming 68% of the annual marine landings and the overall catch rate was 59.12 kg h^{-1}. Multiday trawlers formed 95.96% of the catch and singleday trawlers contributed 4.04% . The catch rate in multiday trawlers was 60.39 kg h^{-1} and in singleday trawlers 46.52 kg h^{-1}. Catch decreased whereas the catch rate increased in 2016 compared to 2015. In West Bengal, 0.78 lakh t was landed by trawlers at catch rate of 29.34 kg h^{-1} forming 29% of the total marine landings. Catch increased by more than double this year, however catch rate remained more or less the same.

Andhra Pradesh

Penaeid prawns with 20.5% was the highest contributor, followed by ribbonfishes 15.1%, croakers 5%, silverbellies 4%, crabs 3.8%, threadfin breams 3.7%, goatfishes 3.3%, *Stolephorus* 2.7%, mackerel 2.8% and non-penaeid prawns 2.6%. Landings of ribbonfishes, croakers, mackerel, threadfin breams, goatfishes, silverbellies, lizardfishes and catfishes were 11700, 3902, 2207, 2848, 2558, 3083, 1641 and 1622 t at catch rates of 2.95, 0.98, 0.56, 0.72, 0.64, 0.78, 0.41and 0.41 kg h^{-1}.

Odisha

Penaeid prawns with 18.1% were the highest contributor, followed by croakers (17.9%) and ribbonfishes (13.4%). The landings of croakers, ribbonfishes, mackerel and catfishes were

Reproductive biology and feeding intensity of dominant resources at Visakhapatnam and Kakinada

Species	Length range (mm)	Mean length (mm)	Sex ratio	Mature %	GSI %	Empty – Trace %	Quarter – Half %	Three fourth – Gorged %
Rastrelliger kanagurta	130-239	194.22	0.96	30.34	3.62	19.16	48.79	32.05
Sardinella longiceps	110-219	158.63	1.24	28.39	4.96	25.38	56.33	18.29
Trichiurus lepturus	380-1079	668.53	1.88	38.27	5.36	46.22	32.68	21.10
Nemipterus japonicus	80-279	168.67	2.12	25.67	4.05	52.65	38.97	8.38
Saurida undosquamis	160-399	235.62	2.38	38.64	5.11	49.75	42.38	7.87
Otolithes ruber	160-399	248.63	1.75	22.38	3.34	44.68	38.94	16.38
Upeneus vittatus	110-189	146.72	1.66	25.92	4.86	48.45	34.68	16.87
Metapenaeus monoceros	101-212	154.68	1.94	32.65	8.38	26.54	57.38	16.08
Loligo duvaucelii	50-179	101.24	1.62	38.72	8.21	45.67	28.86	25.47
Katsuwonus pelamis	320-679	532.19	1.84	29.65	2.02	64.32	29.65	6.03
Thunnus albacares	360-1819	734.96	2.16	26.34	1.82	56.78	32.86	10.36
Scomberomorus guttatus	240-579	383.68	2.35	19.84	2.49	49.74	35.7	14.56
Scomberomorus commerson	260-1159	562.18	1.68	11.46	1.64	56.78	28.65	14.57
Sphyraena jello	160-759	348.64	2.38	18.64	3.32	48.76	37.93	13.31

Reproductive biology and feeding intensity of dominant resources at Digha

Species	Length range (mm)	Mean length (mm)	Sex ratio	Mature %	GSI %	Empty – Trace %	Quarter – Half %	Three fourth – Gorged %
Rastrelliger kanagurta	140-239	184.42	1.28	42.56	4.12	34.54	57.93	7.53
Sardinella longiceps	120-209	164.68	0.88	34.94	5.26	38.64	42.68	18.68
Trichiurus lepturus	420-919	622.78	1.39	32.15	4.18	35.64	38.68	25.68
Nemipterus japonicus	140-269	214.39	2.31	38.64	4.48	40.73	34.58	24.69
Saurida tumbil	190-369	287.45	1.22	28.58	5.12	32.83	48.93	18.24
Otolithes ruber	180-369	256.62	2.24	26.68	3.38	36.96	45.16	17.88
Upeneus sulphureus	110-199	154.68	1.16	54.74	5.68	28.75	55.96	15.29
Penaeus monodon	128-238	184.62	1.58	23.37	7.33	38.83	34.67	26.50
Loligo duvaucelii	60-184	109.67	1.26	43.68	9.35	46.37	39.51	14.12
Cynoglossus arel	130-289	222.37	1.37	12.56		54.67	38.17	7.16

Population parameters and exploitation status of dominant resources along northeast coast

Species	L_∞(mm)	k	M	F	Z	E	L_c (mm)
Rastrelliger kanagurta	25.88	0.64	1.28	1.12	2.40	0.47	16.33
Sardinella longiceps	24.02	0.79	1.55	1.92	3.47	0.55	11.12
Trichiurus lepturus	110.63	0.21	0.44	0.58	1.02	0.57	35.49
Nemipterus japonicus	32.07	0.42	1.06	0.95	2.01	0.47	12.64
Saurida tumbil	38.37	0.44	0.86	0.93	1.79	0.52	19.67
Saurida undosquamis	44.72	0.28	0.67	0.89	1.56	0.57	17.59
Otolithes ruber	44.23	0.38	0.94	1.17	2.11	0.55	19.38
Upeneus sulphureus	20.18	0.97	1.84	2.33	4.17	0.56	13.86
Upeneus vittatus	18.76	1.03	2.11	1.93	4.04	0.48	11.61
Cynoglossus arel	33.15	0.29	0.68	0.59	1.27	0.46	18.43
Loligo duvaucelii	20.06	0.38	0.64	1.02	1.66	0.61	8.15

15263, 11384, 3658 and 2207 t at catch rates of 10.69, 7.97, 2.56 and 1.55 kg h^{-1}.

West Bengal

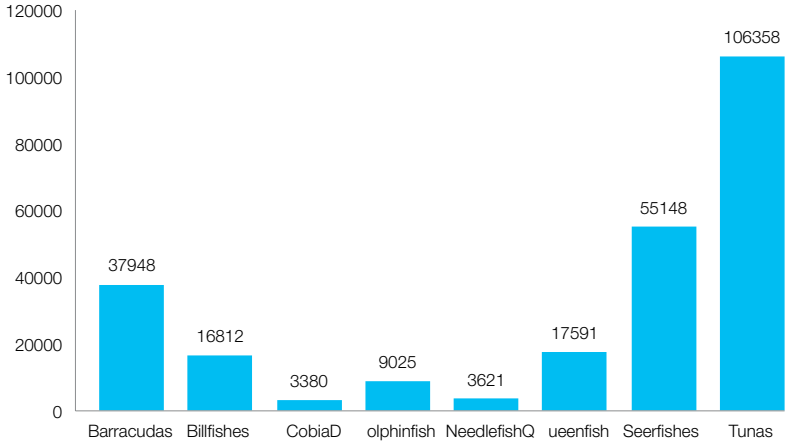
Penaeid prawns with 16% contributed the most, followed by croakers (9%), *Coilia* (6%), Bombayduck (5%), cuttlefish and lesser sardines (4%) and *Setipinna*, hilsa (3%). The landings of croakers, catfishes, *Harpadon nehereus*, mackerel, silverbellies and soles were 7334, 3227, 4252, 2419, 687 and 2167 t at catch rates of 2.77, 1.22, 1.61, 0. 91, 0.26 and 0.82 kg h^{-1}.

Longline catch of yellowfin tuna

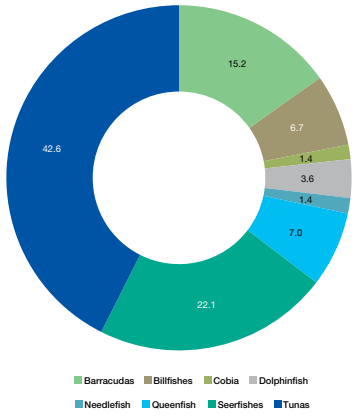
Large pelagic resources

Research Project: FISHCMFRISIL201200700007

Large pelagics (LP) landings along the Indian mainland coast and Lakshadweep Island territories comprising tunas, billfish, seerfish, dolphinfish, cobia, barracuda, queenfish, and fullbeaks increased during the year 2016. Total LP catch of the country including Island territories in 2016 was 2,49,883 t. Catch of LP in the mainland was 2,34,143 t which contributed 6.5% of the total marine fish catch. Large pelagics fishery along Lakshadweep and Andaman territories were supported mostly by tunas. Along the mainland region, landings improved marginally (2.2%). Catch of all groups except seerfish, dolphinfish and fullbeaks improved. Tuna followed by seerfish and barracuda were the major contributors; which together represented about 80% of LP catch. Major maritime states that contributed to the LP fishery were Tamil Nadu,



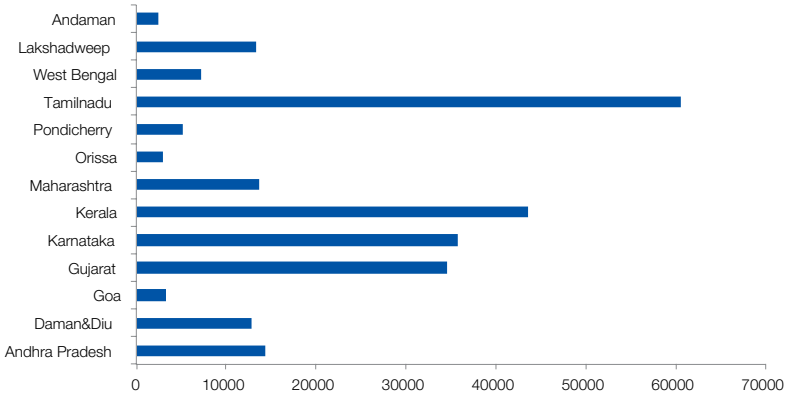
Resource-wise landings (t) of large pelagics from Indian waters



Group-wise composition (%) of large pelagics during 2016

Kerala, Karnataka and Gujarat. Over the years, the LP landing has steadily increased. It was 62,000 t in 1985, 1,98,991 t in 2012, 2,10,154 t in 2015 and 2,34,143 t in 2016. The trend in production indicated that, LP fishery as such is in a developing state and there is scope for increasing production by extending fishing to distant waters within the Indian EEZ.

Tuna: Tuna represented 42.6% of the total large pelagic production with a total landing of 1,06,359 t. Fishery was supported by five species of neritic tunas (56.7%) and 4 species of oceanic tunas (43.3%). Major part of tuna catch was by *E. affinis* (35.7%) among neritic tunas and *K. pelamis* (25.8%) among oceanic tunas. Kerala (22.4%) followed by Tamil Nadu (19.3%) Karnataka (15.8%) and Lakshadweep (12.6%) were the major contributors to the catch. Major share of the catch (79%) was from the southern coast of India. Mean size of all species were



State-wise catch of large pelagics

Landings (t) of large pelagic resources in maritime states of India

Resources	AP	D & D	Goa	Guj	Ktka	Ker	MH	Or	Pond	TN	WB	L D	A & N
Barracudas	1597	1576	301	4537	4955	3823	903	180	2475	17412	190	-	-
Billfishes	1474	94	0	1320	160	5560	330	80	122	7609	62	-	-
Cobia	64	505	0	776	302	452	305	32	39	253	652	-	-
Dolphinfish	183	2141	0	3108	266	2096	327	9	113	783	0	-	-
Needlefish	154	45	47	437	248	351	406	49	19	1864	0	-	-
Queenfish	690	1224	69	4762	1358	237	2061	784	201	3115	3091	-	-
Seerfishes	3839	2032	194	8951	11618	7318	5264	1740	1944	9032	3216	-	-
Tunas	6383	5282	2611	10699	16801	23816	4120	78	290	20482	57	13352	2388
Total	14383	12899	3221	34589	35708	43654	13716	2951	5204	60550	7269	13352	2388

larger than the size at maturity. Spawning stock biomass (SSB) of species was above 30%, except for *A. rochei* indicating that stocks remain healthy. Biologically most species were exploited at ideal condition.

Important biological reference points of major exploited tuna species

Species (%)	L_r	L_{max}	Mean	L_m
T. albacares (17.4)	44	167	104.3	57.6/94.3
K. pelamis (25.8)	24	87	44.6	40.9
G. unicolor (0.10)	48	141	73.4	69.0
T. tonggol (7.9)	42	83	51.7	49.8
E. affinis (35.5)	24	69	39.5	37.7
A. thazard (6.5)	22	57	37.2	29.7
A. rochei (6.4)	13	36	22.9	23.6
S. orientalis (0.5)	29	57	41.4	42.0
T. obesus (0.06)	133	164	147.4	-

Skipjack catch landed by gillnetters at Kochi

Seerfishes: Five species of seerfishes constituted 22.1% of the LP with a production of 55,148 t. Catch dipped marginally (1.7%) during the year. *Scomberomorus commerson* (68.2%), *Scomberomorus guttatus* (31.3%) and small quantities of *Scomberomorus lineolatus, Scomberomorus koreanus* and *Acanthocybium solandri* supported the fishery. Sothwest coast (34.7%) was the major contributor to the catch followed by northeast (29.5%), southeast (26.9 %) and northwest coast. Spatial abundance of species varied considerably with wider distribution for, *S. commerson* along the entire coast, whereas *S. guttatus* was more abundant towards northern areas of east and west coasts. Wahoo formed a fishery only along the southern most coast. The landing of seerfishes has been stagnating around 49,300 t since 2000 with wide fluctuation. Extension of efforts to deeper waters added to the increased contribution of large kingseer and wahoo. However, production from coastal waters showed marginal decline.

Important biological parameters of major exploited seerfish species

Species and % contribution	L_r	L_{max}	Mean	L_m
S. commerson	16	158	68.6	69.4
S. guttatus	27	98	48.2	37.4
A. solandri	65	128	93.7	-

Barracudas contributed 15.2% of LP landings with a production of 37,948 t. Catch registered uptrend (26.2%) during the year. Barracudas were landed along the entire coast with major contribution from southeast coast (56.6%) followed by southwest coast and northwest coast. Fishery was supported by twelve species, dominated by *Sphyraena putnamae* and *Sphyraena jello*.

Billfishes: Billfishes with a catch of 16,812 t contributed 6.7% to the LP catch. The catch registered an uptrend (39.7%) during the year. Fishery was supported by five species; three

Important biological parameters of major exploited barracudas

Species	L_r	L_{max}	Mean	L_c	L_m
S. putnamae (24.7%)	28	89	47.6.6	46.4	51.6
S. barracuda (2.4%)	52	134	78.5	6.6	68.4
S. jello (14.5%)	27	139	79.2	63.4	71.7
S. *obtusata* (9,3%)	13	28	20.4	22.8	21.8
S. arabiansis (4.7%)	44	154	118.7	51.0	23.8

species of marlins and one species each of sailfish and swordfish. Most common in the catch were Marlins, *Istiompax indica* and *Makaira mazara*; sailfish, *Istiophorus platypterus* and swordfish, *Xiphias gladius*. Short-bill marlins *Tetrapturus* spp. also formed part of the regular catch. Marlins dominated the catch (42.5%), followed by sailfish (36.5%), and swordfishes. Bill fishes were landed along the entire coast with major share from southeast coast (54.8%), followed by southwest coast (34%).

Important biological parameters of major exploited billfishes

Species	L_r	L_{max}	Mean
Istiompax indica (22.2%)	138	306	214
Istiophorus platypterus (36.5%)	68	227	154.2
Xiphias gladius (20.87%)	63	196	111.3
Makaira mazara	84	234	143

Longline catch of swordfish

Dolphinfishes: Dolphinfishes (mahi mahi) contributed 3.6% of the LP landings with a catch of 9,025 t. Fishery was supported by two species; *Coryphaena hippurus* and small quantities of *Coryphaena equiselis*. Catch showed a marginal decline during the year. The species were landed all along the coast, but the major (88%) contribution was from the west coast. Contribution from northwest coast alone accounted for 62.8% of the total catch.

Important biological parameters of major exploited dolphinfishes

Species	L_r	L_{max}	Mean	L_m
C. hippurus (88.1%)	28	158	68.7	43.7
C. equiselis (11.9%)	24	55	40.8	24

Cobia: Cobia represented 1.4% of LP catch with a production of 3,380 t. Fishery was by a lone species; *Rachycentron canadum*. Landing showed steady increase over the period. Cobia was landed along the entire coast with major share (46.9%) from northwest coast. Appreciable quantity was landed along southwest coast (22.3%) and northeast coast (20.2%).

Important biological parameters of cobia.

Species	L_Q	L_{max}	Mean	L_m
R. canadom	32	163	78	68

Queenfishes and rainbow runner: Queenfishes formed 7% of the total LP catch with a production of 17,591 t. Fishery was supported by four species. Major share of the catch was by *S. lysan* (40.3%) and *S. commersonianus* (27.7%). Catch registered marginal improvement. Landings were reported from the entire coast with the major share (45.7%) from northwest coast.

Rainbow runner fishery was supported by a lone species *Elagatis bipinnulata* which formed 0.3% of the total LP catch with a production of 5,24 t. Major share of the catch was from

Mahimahi landed at Kochi by longliners

Important biological parameters of rainbow runner

Species	L_r	L_{max}	Mean	L_m
E. bipinnulata (3.4%)	21	98	52.6	64.3

Important biological parameters of major exploited queenfishes

Species	L_r	L_{max}	Mean	L_m
S. commersonianus (27.3%)	28	126	70.6	58.6
S. lysan (43.2%)	26	69	39.6	39.2
S. tol (12.4%)	16	41	33.2	26.2

southwest coast with Kerala alone contributing 62% of the resource catch. Catch improved by 80% during the year.

Needlefishes: Contributed 1.7% to LP catch with a production of 3,621 t. Catch registered marginal decline. Catch highly fluctuated over the years and showed continuous decline during the decade. Though landed along the entire coast, major share (56.3%) was from southeast coast. Tamil Nadu alone contributed 51.4% of the resource catch. Six species supported the fishery, dominated by *Ablennes hians* (52.6%), followed by *Tylosurus crocodilus* (23.7%), and *Strongylura incisa* (14.1%).

Important biological parameters of major exploited needlefishes

Species	L_r	L_{max}	Mean	L_m
A. hians (52.6%)	51	115	83.4	65.8
T. crocodilus crocodilus (23.7%)	50	133	91.6	73.8
Strongylura leiura (0.03%)	50	133	91.6	69.6

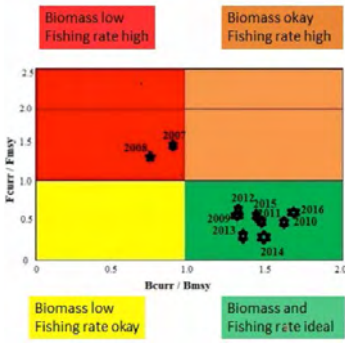
Biology and population parameters

Biological observations indicated that mainly adults constituted the catch except in the case of kingseer and swordfish. Trawls and gillnets landed young ones of kingseer in large numbers

Population parameters of major species of large pelagics

Group/Species	Growth parameters			Length-Weight relationship (cm, g)		Length at maturity (L_m)
	L_∞	K	t_o	a	b	
Tuna						
E. affinis	89.20	0.560	-0.0317	0.0254	2.889	37.70
A. thazard	58.70	1.200	-0.0075	0.0033	3.467	29.70
A. rochei	42.30	0.610	-0.0337	0.0076	3.249	23.60
S. orientalis	74.75	0.680	0.0000	0.0087	3.100	42.00
T. tonggol	123.50	0.524	-0.0319	0.0147	3.040	49.80
T. albacares	211.10	0.270	-0.0560	0.0208	2.986	57.6/94.3
K. pelamis	97.60	0.485	-0.0012	0.0109	3.147	41.00
G. unicolor	163.60	0.430	-0.1200	0.1011	3.065	69.00
Seerfishes						
S. commerson	168.50	1.250	-0.0724	0.1542	2.814	69.40
S. guttatus	75.00	1.100	-0.0187	0.0229	2.782	37.40
A. solandri	158.00	0.340				
Billfishes						
Istiophorus platypterus	310.2	0.33	0.0240	2.650	131.2	
Istiompax indica *	342.3	0.18	103.0			
Xiphias galdius *	217.6	0.14	95.7			
Carangids						
*Scomberoides commersonnianus**	130.1	0.21	66.1			
Scomberoides lysan *	81.7	0.29	40.0			
Scomberoides tala *	65.2	0.38	32.7			
Scomberoides tol *	46.00	0.98	-0.0136	0.0174	2.746	26.0
Elagatis bipinnulata *	101.8	0.83	0.0206	2.848	53.0	
Cobia						
Rachycentron canadum	180.00	0.720	-0.0174	0.0071	2.984	68.0
Needle fishes						
Strongylura leiura *	138.2	0.58	69.6			
Tylosurus crocodilus *	145.3	0.51	0.00067	3.252	73.6	
Ablennes hains *	143.3	0.49	0.0007	3.315	65.8	
Barracuda						
Spyraena barracuda *	142.2	0.26	68.4			
Spyraena putnamae *	0.0109	2.850	51.6			
Spyraena jello *	188.4	0.28	71.7			
Sphyraena obtusata *	45.8	0.71	23.80			
Mahimahi						
Coryphaena hippurus *	143.2	0.370	43.7			

and hooks and lines and gillnets, the young ones of swordfishes. Gut analysis showed that all LP species were highly predatory and carnivores in feeding habit. Food was supported by pelagic finfishes, crabs, oceanic squids/octopus and meso-pelagics.



Kobe plot depicting the present fishing level and biomass level with respect to MSY of yellowfin tuna

Stock status of yellowfin tuna

Conventional stock assessment indicated that yellowfin tuna is exploited at ideal level. Kobe analysis indicated that yellowfin biomass is abundant and sufficient for maintaining sustainable production. Fishing rate is also at a much lower level than that required to produce MSY from the present fishing ground. The Kobe outcome suggested that yellowfin tuna stock is not subject to overfishing.

The situation suggests considerable scope for increasing yield from the present grounds. There is also scope for enhancing production by extending fishing operations to other less exploited areas like Andaman and Lakshadweep seas.

Clam fishery in Vembanad Estuary, Kerala

Bivalve fisheries and management

Research Project: FISHCMFRISIL201201200012

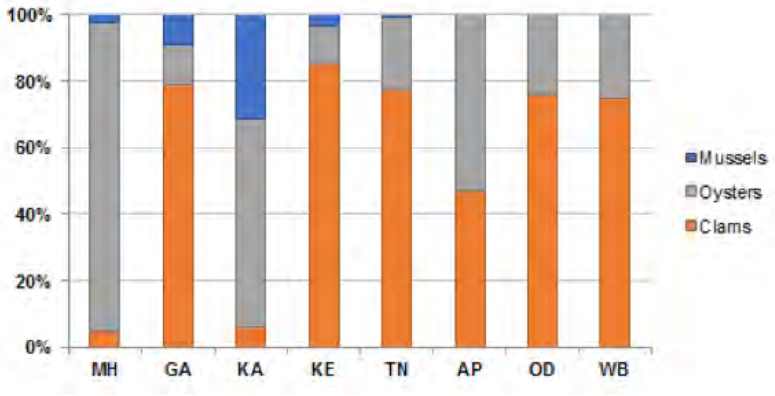
National bivalve production

Annual bivalve catch from the states of Kerala (KE), Karnataka (KA), Goa (GA), Maharashtra (MH), Tamil Nadu (TN), Andhra Pradesh (AP), Odisha (OD) and West Bengal (WB) was estimated at 84,483 t. Bivalve production registered a decrease by 9% when compared to the fishery in 2015 (92,513 t). The estimation covered major landing centres in Mochemaad, Vengurla, Devbag, Achara, Devgad, Taramumbari, Pernem (N. Goa), Canacona (S. Goa), Mandovi, Zuari,

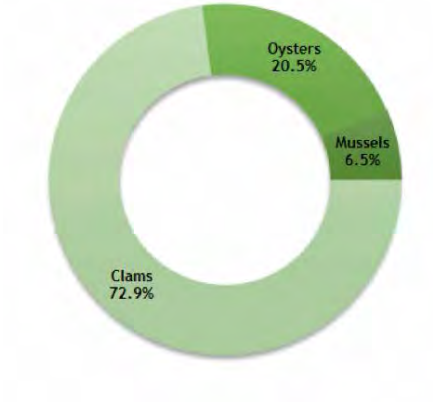
Karwar, Uttara Kannada, Dakshina Kannada, Udupi, Malabar region, Vembanad, Ashtamudi, Vizhinjam, Kavanadu, Tuticorin, Chennai, Kakinada, Bahuda, Chilka, Chaumukha, Contai and Frazerganj. Clams dominated the fishery contributing 72.9% to the annual bivalve production followed by oysters 20.5% and mussels 6.5%. Clam fishery registered a decrease by 20%, while oyster and mussel fishery increased by 59% and 42% respectively.

Estimated bivalve fishery production (t) in India by state

Year	MH	GA	KA	KE	TN	AP	OD	WB	Total
2016	1418	132	9,936	64,015	3,609	2,124	2,050	1,200	84,483
2015	943	-	3,845	85,768	1,304	653	-	-	92,513



Contribution of bivalve groups to the total landings by State



Contribution of clams, oysters and mussels to all India bivalve production

Heavy spat fall of *Perna viridis* was observed in intertidal and subtidal mussel beds along Goa, Karnataka and Kerala coasts during September-December 2016. The average size of the mussel spat was 8.7 mm in September. Mussel spat settlement was also observed on oyster shells as well as on sandy substratum near barmouths and estuaries along southwest coast.

Large scale settlement of the spat of brown mussel *Perna indica* was observed along Vizhinjam coast from August 2016. Similar settlement of spat was observed at Perumathura in Kerala; Kadiyapattanam and Enayam in Tamil Nadu. Along with brown mussel spat, stray occurrence of green mussel spat was also observed in these places. The deficient rainfall (-62%) and prevailing higher salinities during post-monsoon probably led to heavy settlement of mussel spats during the period.

Mussel spat settlement on intertidal rocks in Someshwara, Karnataka

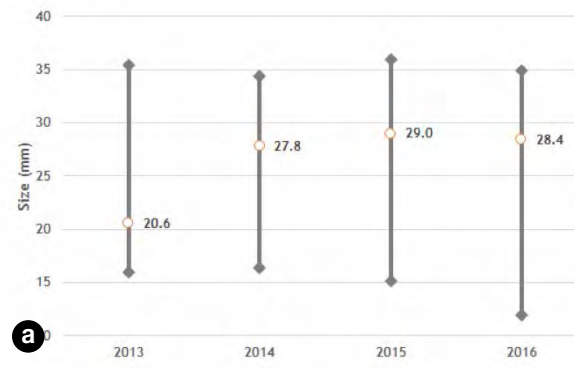
Though the inter-state transportation of clams to Karnataka and adjacent states by road and by rail from estuaries of Kerala has a long history, a prominent shift in the market channels for short-neck clam of Ashtamudi and Kayamkulam lakes was observed during 2016. Clam transportation in large quantities, which started in 2015 continued in 2016 and targeted markets extending from Kasaragod (North Kerala) bordering Karnataka up to Maharashtra. Clam fishers realised about ₹200-260 per kg of whole clam which was 2.5-3 times the price in south Kerala. Drastic reduction in clam production in the estuaries of Karnataka, due to poor spat settlement and post-settlement mortality led to the increased demand for clams. The clams were initially transported to Karnataka and relayed in estuaries at Coondapura for a minimum period of 2 days. Stressed clams which remained on top of the relayed substratum, were collected, sorted and packed in 10 kg bags at first, for sale in local and Goan markets. The healthier clams, buried in the substratum were packed similarly and transported to Ratnagiri and Mumbai markets. The estimated survival rate of the stressed clams collected from the top layer of the Coondapura Estuary was 38-48%.

a. Transportation of relayed clams to Goa and Maharashtra from Coondapura Estuary
b. Clam relaying areas demarcated in Coondapura Estuary

Major share of the bivalve production of the country was reported from the State of Kerala (75.8%). Clams formed 85.3% of bivalve production in the State followed by edible oysters (11.1%) and mussels (3.6%). Black clam, *Villorita cyprinoides* was the most important clam species exploited in India (73.8%), with Vembanad Lake contributing 81.7% to the fishery. *V. cyprinoides* catch and catch rate in Vembanad decreased by 6.8% and 20% respectively in 2016.

Exploitation of juvenile clam '*mallikakka*' (12-18 mm) was observed in Vaikom and Pookaitha of Vembanad for 4-5 months. Mean size of *V. cyprinoides* in the fishery decreased from 29 mm in 2015 to 28.4 mm in 2016. Heat shucked juvenile clam flesh were marketed to local

a. Mean size of *Villorita cyprinoides* in Vembanad fishery
B. Shucked '*mallikakka*' marketing in Vembanad Estuary, Kerala



Clam biomass densities per m² in the northern part of Thanneermukkom barrage, Vembanad Lake

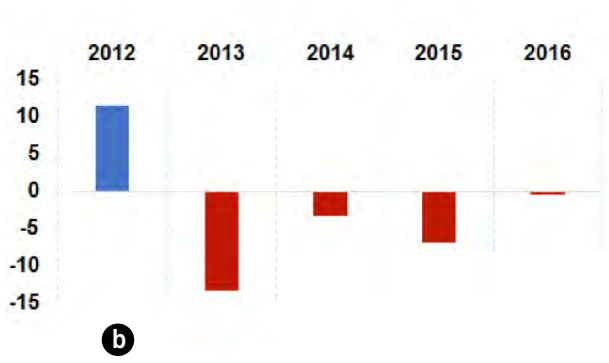
Stations	2012	2015	2016
East	>500	860	362
Middle	>500	4486	9889
West	>600	1080	1527

shrimp farms at ₹25 per kg, when the shucked adult clams fetched ₹100 per kg. The economic loss due to juvenile exploitation has been estimated as 4 times in terms of weight and 15.6 times in terms of value.

Clam biomass survey during 2016 in lease area of "Vaikom lime shell co-operative society" of Vembanad, recorded higher clam biomass, when compared to the surveys conducted in 2012. Black clam densities were influenced by the sediment texture, organic carbon content, organic carbon to reduced sulphur (C/S) ratio, particulate organic matter (POM) and pH.

In Ashtamudi Estuary, the fishery of *Paphia malabarica* during March to November 2016 registered a decreasing trend by 13%. Catch rate of shell-on clam that was 221.8 kg unit^{-1}, reduced by 14%. Clams were exploited above the MLS of 20 mm as the size range in the fishery was 22-40 mm. The fishing ban continued during December 2015-February 2016; however, the mature clams were abundant during the fishing period indicating a shift in the spawning. Peak spatfall was observed in March and in September.

Clam biomass surveys were undertaken in Ashtamudi Lake covering the five clam fishing zones. Adaptive management measures for prudent exploitation of *P. malabarica* adopted in 2015 in Ashtamudi was extended during 2016. The 20-member Council with District Collector of Kollam District as Chairman met 4 times during the year. Based on reports of poor biomass in clam beds by CMFRI, the council continued with one additional day fishing holiday per week. Though the targeted reduction in fishing effort was ~15%, the actual fishing effort reduction during 2015-16 was only by 7.18%.



a. Clams transported in gunny bags from Muthalapozhi Estuary for inter-state marketing
b. Trends in annual fishing efforts in Ashtamudi clam fishery during 2012-16

Contribution of bivalve catches from the Malabar Coast to the state production reduced from 40% in 2015 to 25% in 2016. Clam, oyster and mussel fishery recorded a decrease by 60.3% from Malabar region. *V. cyprinoides* dominated the clam fishery contributing 94.6% to the total landing in the region. *P. malabarica* was recorded from Dharmadom Estuary alone, contributing only 3% to the clam production. Poor spat settlement of *P. malabarica* and mortality of settled spats resulted in 68% decrease in clam production. Green mussel *P. viridis* catch in the region, contributed to 77% of the mussel production from the State.

Brown mussel fishery was observed only along the Vizhinjam Coast. No regular brown mussel fishery was observed at Mulloor due to the dredging activity for Vizhinjam International Seaport. Clam exploitation has emerged during the recent past at Muthalapozhi Estuary, due to demand in Karnataka, Goa and Maharashtra.

Karnataka (11.8%), Tamil Nadu (4.3%), Andhra Pradesh (2.5%), Odisha (2.4%), Maharashtra (1.7%), West Bengal (1.4%) and Goa (0.2%) contributed nearly 24.2% to the total bivalve production. Clams dominated the fishery in Goa (*P. malabarica*), Odisha and West Bengal (*Meretrix meretrix*). Oyster *Crassostrea* spp. was the major contributor in Karnataka and Andhra Pradesh, while *Saccostrea cucullata* dominated in Maharashtra.

Ornamental gastropods

Research Project: FISHCMFRISIL201201300013

Gastropod fishery, status and potential of shellcraft industry were studied in four states *viz.*, Tamil Nadu, Andhra Pradesh, Kerala and Gujarat

Tamil Nadu

The total estimated gastropod landing in Tamil Nadu during 2016 was 1328 t. The highest landing of gastropod was recorded in Cuddalore (447 t) followed by Nagapattinam (371 t), Ramanthapuram (213 t), Kanyakumari (168 t), Tuticorin (103 t) and Tirunelveli (8 t). Among different gears, mechanised trawlnet contributed maximum catch (675 t) followed by multiday trawlnet (509 t). Contributions by other gears to the total catch

were very meager.

In Mandapam, Rameswaram and Chennai landing centres, gastropods were landed by trawlers as bycatch and these resources were exploited throughout the year. At Mandapam, the catch comprised 18 species of gastropods and the estimated catch was 1026 t by 57,620 units in 122 days. The CPUE was 18 kg unit^{-1} and 2.2 kg h^{-1}. Strombids formed around 33% of total landing followed by *Turbinella pyrum* (8%), *Volegalea cochlidium* (8%) and *Tonna* spp. (6%). Other gastropod groups contributed lesser percentage. At Rameswaram, the estimated catch of gastropods comprising 18 species was 1557 t by 62,470 units in 101 days. The CPUE was 25 kg unit^{-1} and 3 kg h^{-1}. Among different species, Naticids formed 19%, Olive shells 12%, Strombids 12%, *Nassarius* spp. 8% and the remaining catch was contributed by other gastropod species. At Chennai, the total estimated landing was 12 t by 19,594 units with CPUE of 1.89 kg unit^{-1}. The catch comprised of 28 species and *Babylonia* spp. (18%) contributed maximum to the fishery followed by *Bufonaria* spp. (13%) and *Ficus* spp. (13%).

Gastropod resources at Kayalpattinam landing centre were exploited mainly by bottom set gillnets/chanknet. *Turbinella pyrum* and *Chicoreus ramosus* were the two gastropod species targeted in this landing centre. Total estimated landings of chanks at Kayalpatinam was 1,15,811 kg by 7,423 units in 276 fishing days. The CPUE was 15.6 kg unit^{-1}. The catch of *C. ramosus* was 62,471 kg forming 54% of the total gastropod fishery of Kayalpattinam and the estimated catch of *T. pyrum* was 53,340 kg contributing 46% to the gastropod landings.

T. pyrum, *C. ramosus* and *Lambis lambis* were landed by diving and hand picking. At Kalavasal, the gastropod fishery comprised mainly *T. pyrum* and *C. ramosus*. The estimated catch of *T. pyrum* and *C. ramosus* was 28,561 kg and 43,593 kg respectively by 6205 units in 277 days. The CPUE of *T. pyrum* was 5 kg unit^{-1} and for *C. ramosus* it was 23 kg unit^{-1}. At Olaikuda, gastropod exploitation was carried out by Vallam and Catamaran. The estimated landing by vallam was 1,59,532 kg by 14,935 units in 145 days. The CPUE worked out was 11 kg unit^{-1}. Estimated landing by Catamaram was 34,718 kg by 27,384 units in 163days (March - October 2016) with CPUE 1.3 kg. *T. pyrum* and *L. lambis* were the targeted species in these centers. In Dhanushkodi and Vedalai, *T. pyrum* was the only targeted gastropod species for exploitation. Gastropod exploitation was carried out only during January and February in Dhanuskodi. In Vedalai, the fishery was during January, February, November and December. At Dhanuskodi, the estimated landing was 53,326 kg by 2052 units in 57 days with CPUE of 26 kg unit^{-1}. The estimated landing at Vedalai was 27,335 kg by 2,745 units in 61 days with CPUE of 10 kg unit^{-1}.

Estimated annual landings of gastropod by diving

Fishing village	Craft	Total catch (t)	Total no. of units	CPUE (kg unit^{-1})	Fishing month
Kalavasal	Vallam	172	6,205	28 kg unit^{-1} 2.3 kg person^{-1}	All months
Olaikuda	Vallam	106	14,935	7.1 kg unit^{-1} 1.8 kg person^{-1}	Mar-Oct
Olaikuda	Catamaram	25	27,384	1 kg unit^{-1} 1 kg person^{-1}	Mar-Oct
Vedalai	Vallam	27	2,745	10 kg unit^{-1} 2.3 kg person^{-1}	Jan, Feb, Nov, Dec
Dhanuskodi	Catamaram	53	2,052	26 kg unit^{-1} 5 kg person^{-1}	Jan, Feb

Exploitation of fossilised chank at Kalavasal

The estimated catch of fossilised chank at Kalavasal was 2,52,989 kg by 14,264 units in 273 days and the CPUE was 18 kg unit^{-1}. The highest catch was observed in the month of February and lowest during the month of May

Gastropod opercula trade

The total estimated gastropod opercula trade comprising three species *i.e.*, *T. pyrum*, *C. ramosus* and *L. lambis* in 8 landing centres was 3,99,087 numbers valued at ₹49,500/-; 2,83,013 numbers valued at ₹38,92,500/- and 3,12,953 numbers valued at ₹6,93,000 respectively.

L. lambis - Operculam

Andhra Pradesh

Total gastropod landing at Kakinada was 3127.8 t, of which 43% was contributed by *Cerethidia* sp. followed by *Murex* sp., *Telescopium* sp. and *Umbonium* sp.. The catch per unit effort was 3551 kg unit^{-1}. In Kancheru the total gastropods landings during the year was 1490.5 t with an average annual landing of 745.25 t. The landing was mainly from the bycatch in gillnets. Whelks formed 38% of the catch. *Babylonia zeylanica*, *B. spirata*, *Harpa major*, *Murex* sp. and *Bursa* spp. contributed more to the landing. The catch per unit effort was 55 kg unit^{-1}. At Visakhapatnam Harbour, the gastropod catch was mainly from trawl as bycatch. Fifty percent of the catch was contributed by *Bursa* spp., 30% by *Ficus* spp. and rest 20% by other species like *Polinices* sp., *Tonna* spp. and *Conus* sp.

Kerala

In 2016, the estimated gastropod landings at Kerala was 1676.6 t. Single day trawlers (MTN) and multiday trawlers (MDTN) operated off Kollam brought an estimated 1541.9 t of gastropods forming 92% of entire Kerala's catch. MTN contributed 83.8% and MDTN contributed 16.2%. *Babylonia spirata* (91.7%.) was dominant in the gastropod fishery followed by *B. zeylanica* (6%) and others (2.3%). Gastropod catch at Kollam was found to increase gradually over the past few years

Biology of important gastropod species landed at Kollam

Babylonia spirata: Length ranged from 21.0 to 55.5 mm, total weight range was 3.52 - 27.42 g, meat weight ranged from 3.47 - 13.89 g and sex ratio (male to female) was 1:14.

Babylonia zeylanica: The length ranged from 22.82 to 49.5 mm, and total weight ranged between 3.99-18 g. The population was dominated by females with sex ratio (male to female) of 1:14. Dominant size in the fishery ranged from 34 to 47 mm

Bursa spinosa: Length and weight ranged from 31.8 to 81.7 mm and 3.96 - 42.8 g respectively. Dominant size in the fishery was 42 -64 mm. Male to female ratio was 1: 3.25.

Bursa margariticula: The observed length and total weight ranged between 21.94 to 63.30 mm and 2.42 to 27.2 g respectively. The sex ratio (male to female) was 1: 1.43.

Gujarat

The major gastropod species landed at Gujarat as bycatch in the gillnetters were *Tibia kurta*, *Babylonia* sp., *Sirratus* sp., *Murax* sp. and *Turbo* sp.

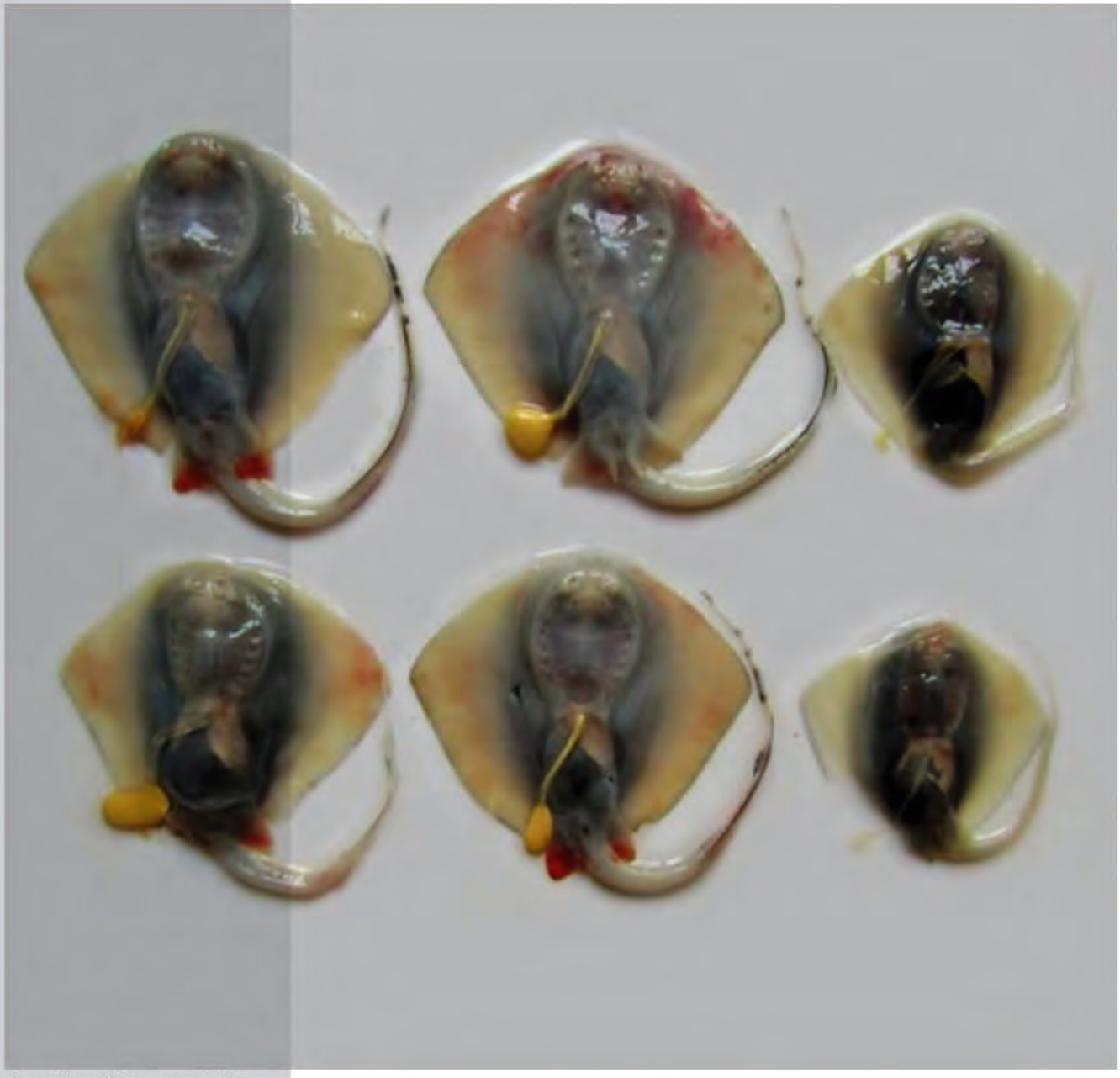
Shellcraft industry

The total estimated quantum of trade of gastropods was 11,000 t (10% was contributed by imports). Around 350 containers each of 20 t were exported/traded annually to 18 countries around the world.

Finished whole gastropod shells for trade

Around 40% (8800 t) of the raw material were procured locally, 50% (11,000 t) from within the country and 10% (2200 t) was imported. Around 20-25 species were imported and the major species imported included *Busycon* sp., *Haliotis* sp., *Cypraea tigris* and *Mitrella* sp. The total operating cost estimated for the shellcraft industry was ₹25 crores.

The total revenue generated from shellcraft industry was around ₹100 crores. On an average, 1% (110 t) of the finished products was sold in the local markets, 24% (2640 t) sold within the country and 75% (8250 t) was exported. The average revenue per t ranged from ₹30,000-45,000 (locally), ₹50,000-60,000 (within India) and ₹90,000-150,000 (import).



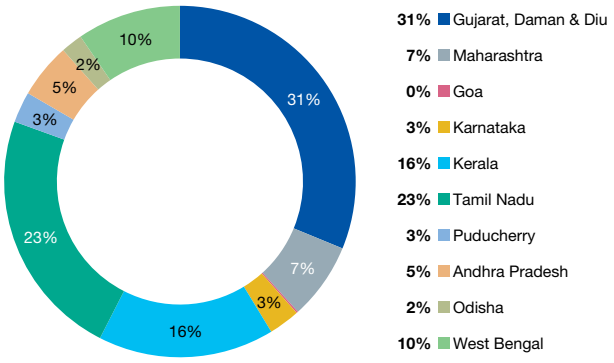
Juveniles of Neotrygon kuhli

Elasmobranch resources

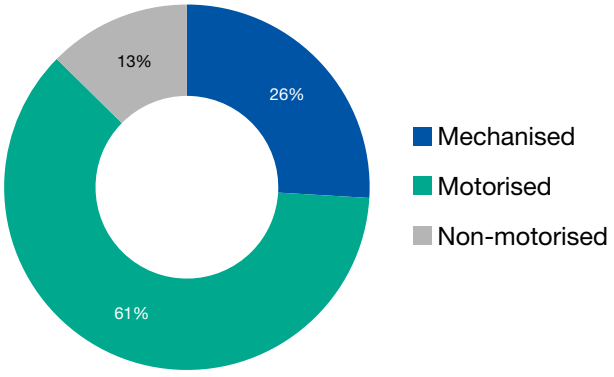
Reaearch Project: FISHCMFRISIL201200500005

Fishery

The production of elasmobranchs in India in 2016 was to the tune of about 52,840.8 t, increasing marginally by about 406 t from the previous year, and forming 1.41% of the total marine fish landings. Sharks formed 45% of the total elasmobranch landings, guitarfishes 3.8% and rays 51.2%. Gujarat, Daman & Diu together accounted for 31.2% while Tamil Nadu and Puducherry together contributed 25.9% of the total elasmobranch landings. Kerala accounted for 16.2%. The motorised sector contributed maximum to the elasmobranch landings, followed by the mechanised and the non-motorised sectors.



State-wise contribution to elasmobranch landings in India (2016)

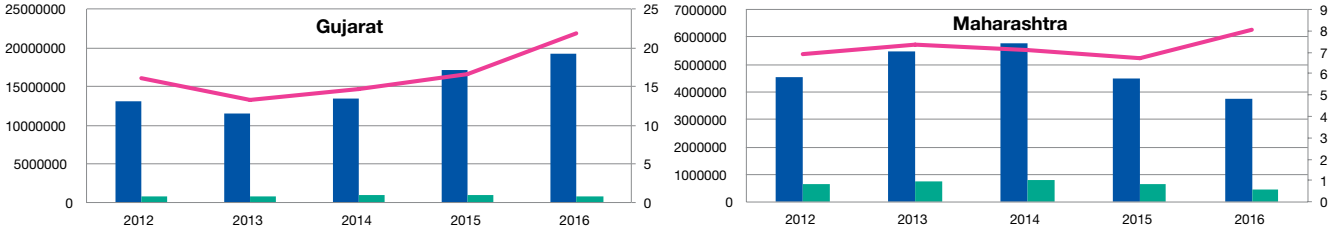


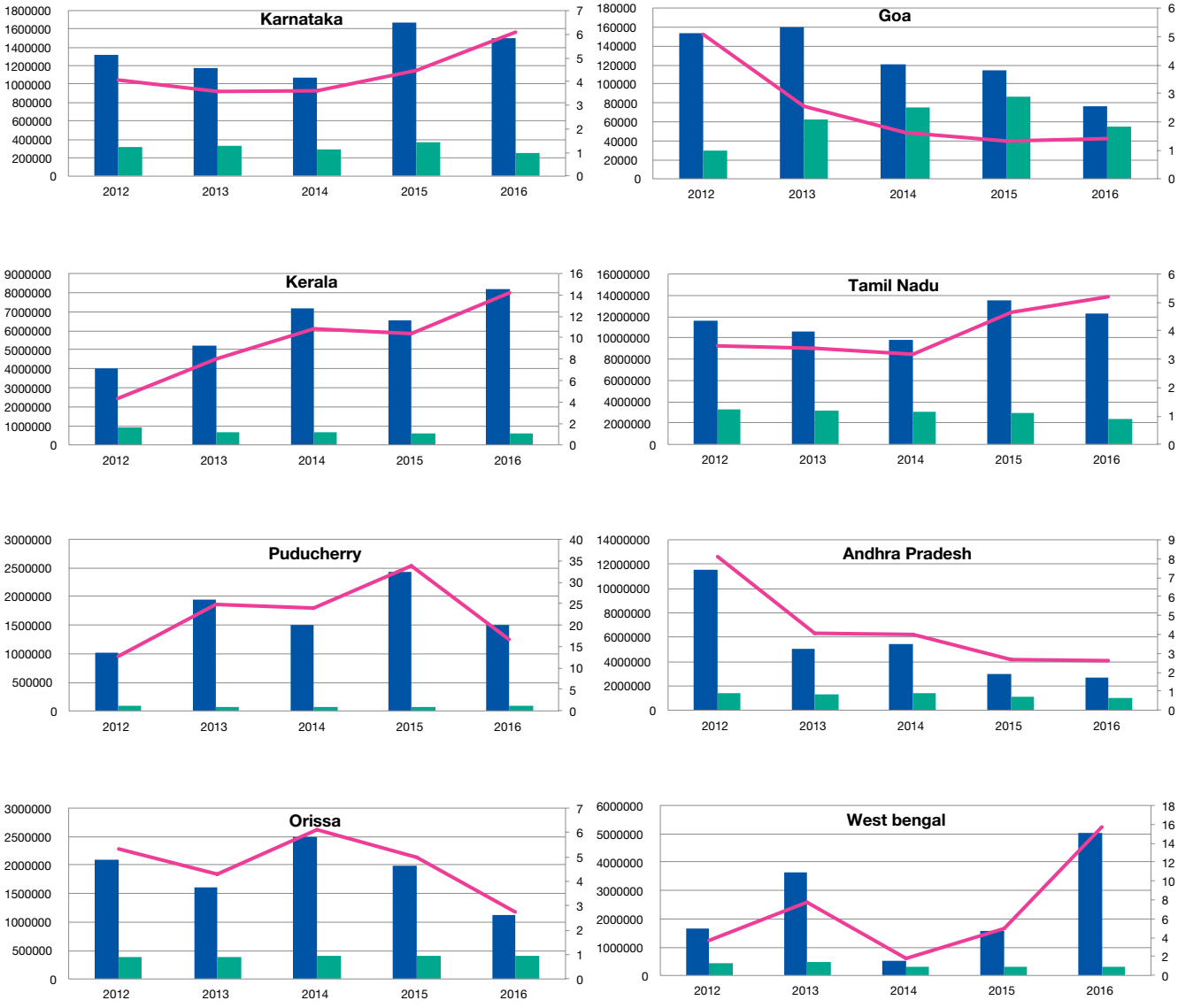
Contribution of different sectors to elasmobranch landings in India (2016)

An estimated total of 16493.3 t of elasmobranchs were landed in Gujarat, Daman & Diu during 2016, declining by 3.5% from the previous year. In Maharashtra, the elasmobranch landing was 3,740.9 t with a decrease of 16.4% and in Karnataka & Goa the landing was 1,592 t declining by 11.4% from the previous year. In Kerala, a total of 8,564.2 t of elasmobranchs were landed, registering an increase of 30.5%. The landing was 13,669.7 t in Tamil Nadu & Puducherry and 2,670.3 t in Andhra Pradesh registering a decrease of 14.3% and 10.7% respectively. In Odisha, 1,054.2 t of elasmobranchs were landed showing a decrease of 47.1% from the previous year. An estimated total of 5,056.4 t of elasmobranchs were landed in West Bengal, registering yet another sharp increase of 221.1% from the previous year.

Over the five-year period 2012-2016, there has been an increasing trend in elasmobranch production in all the states except Maharashtra, Goa, Andhra Pradesh and Odisha, while the CPUE has shown an increase in Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu and West Bengal.

Five-year trend in state-wise elasmobranch landing, effort and CPUE (2012-2016)





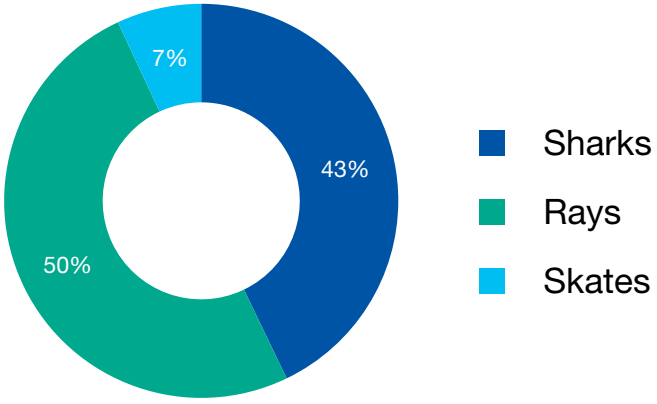
Five-year trend in state-wise elasmobranch landing, effort and CPUE (2012-2016)

Species composition

Rays dominated, contributing 50% of the elaslmobranch landings, while sharks formed 43% and skates mostly represented by guitarfishes, formed only 7%. Sharks were the dominant group along the west coast, while rays were dominant along the east coast.

Sharks were represented by members of the families Carcharhinidae, Triakidae, Sphyrnidae, Echinorhinidae, Hemiscylliidae, Alopiidae, Lamnidae, Centrophoridae, Squalidae and Stegostomatidae. The ray fishery was dominated by Dasyatidae, Mobulidae, Myliobatidae, Gymnuridae and Rhinopteridae. Guitarfishes landed along the coast mostly belonged to families Rhinidae and Rhinobatidae.

Cochin Fisheries Harbour (CFH) remained the hub of shark landings, with catches from other parts of the coast also being landed there. Maximum species diversity of sharks has been recorded at CFH during the period 2012-16.



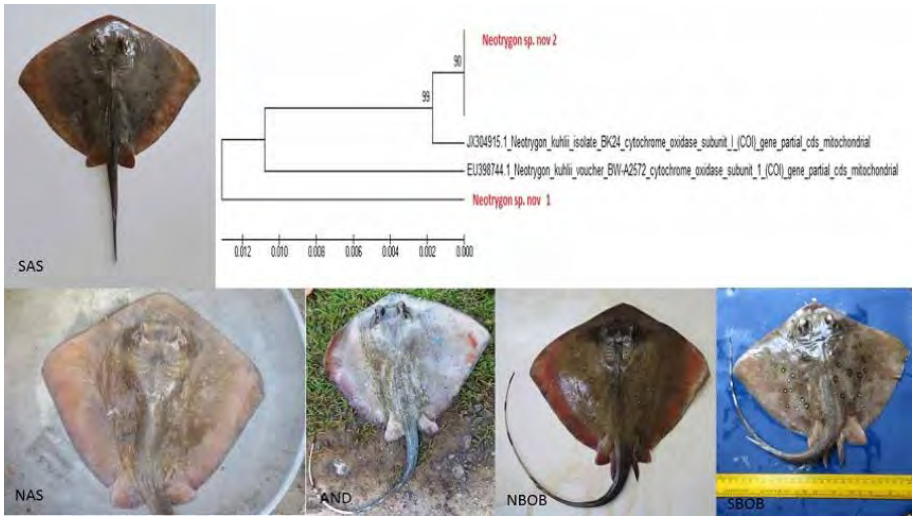
Group-wise contribution of elasmobranchs landed in India during 2016

Species composition of sharks landed at Cochin Fisheries Harbour during 2012- 2016

Species	Total catch (kg)	% in landings
Carcharhinus falciformis	4850947	34.5
Carcharhinus longimanus	1504400	10.7
Carcharhinus amblyrhincoides	264305	2.0
Carcharhinus brevipinna	344153	2.5
Carcharhinus leucas	748515	5.3
Carcharhinus limbatus	243395	2.0
Carcharhinus albimarginatus	183485	1.3
Carcharhinus sorrah	178978	1.3
Carcharhinus plumbeus	13764	0.09
Galeocerdo cuvier	1042186	7.0
Sphyrna lewini	892371	6.35
Sphyrna zygaena	128555	0.91
Sphyrna mokarran	3998	0.02
Alopias superciliosus	901247	6.42
Alopias pelagicus	995734	7.0
Stegostoma fasciatum	203457	1.0
Isurus oxyrinchus	771045	5.5
Isurus paucus	11041	0.07
Nebrius ferrugineus	207302	1.47
Triaenodon obesus	293306	2.08
Echinorhinus brucus	131110	0.93
Prionace glauca	115084	0.8
Loxodon macrorhinus	5082	0.03
Neohariata pinnata	5222	0.04
Hexanchus griseus	5294	0.04
Total	140,43,976	

Biology

Sphyrna lewini : At Mangalore, the length range of female was 42.5-96.0 cm with a mean length of 54.9 cm. All the specimens examined were in the immature or maturing stage. No mature specimens were observed during the period of study. It could be assumed that the fishes caught along the coast of Karnataka were juveniles as the females attain maturity



Taxonomic clarification on *Neotrygon* species complex

around 200-250 cm (TL) while males reach maturity at smaller sizes (range 128 – 200 cm TL). The length weight relationship of *S. lewini* was calculated as W=0.003533 L 3.07015 (M); W= 0.003517 L 3.073685 (F); W= 0.003573 L 3.068464 (pooled). Analysis of covariance showed that the slopes did not differ significantly between the sexes for the juveniles. The sex ratio of *S. lewini* was 1: 0.96. More than 80% of the diet consisted of fishes followed by cephalopods. Major prey species were found to be threadfin breams, lizardfishes, anchovies and silverbellies. Stock assessment of *S. lewini* was done during the period. The data collected from all along the coast was taken for analysis. The L_{∞} was estimated at 498.2 m and K was 0.08 for *S. lewini* in Indian waters. The total mortality (Z) was 0.46, natural mortality (M) was 0.16 and fishing mortality was 0.30. Exploitation rate was 0.69.

Gymnura poecilura : At Visakhapatnam, length at maturity for female *Gymnura poecilura* was estimated at 51 cm disc width. Average uterine fecundity for the species was 3.3. IRI studies indicated that anchovies were the primary diet component of *G. poecilura* followed by *Acetes* sp. and croakers.

Rays: At Mandapam, the gut contents of rays mostly consist of crustaceans, cephalopods and semi-digested whole fishes such as, lethrinids, silverbellies, sardines, goatfishes and

Biological characteristics of the six CITES listed species on which the NDF study was carried out

Biological parameters	*C. longimanus*	*S. lewini*	*S. mokarran*	*S. zygaena*	*M. birostris*	*M. alfredi*
Average life span	23.17 years	41.6 years	20-30 years	18-21 years	>20 years	>31 years
Maximum size (recorded globally)	4 m TL	4.3 m TL	6.1 m TL	5 m TL	9.1 m DW	5 m DW
Maximum size (recorded in India)	2.65 m TL	3.85 m TL	2.5 m TL	4 m TL	6.8 m DW	Juveniles only
Size at maturity (female)	1.87 m	1.4-1.65 m	2.1-2.38 m	2.65 m	4 m disc width	3.7-3.9 m DW
Age at maturity (female)	7.36 y	3-4 y	8-8.2 y	6-8.8 y	15-20 y	6-8 y
Natural mortality rate	0.18 (low)	0.14-0.19 (low)	0.08 (low)	0.1-0.06 (low)	0.012-0.04 (low)	Low
Number of young per year per mature female	9-15	40	30-40	30-40	1	1 every 2-5 years
Population productivity	Very low	Low	Low	Moderate	Very low	Very low
Feeding behaviour	Top predator	Top predator	Top predator	Top predator	Top predator	Top predator
	Trophic level 4.2	Trophic level 4.1	Trophic level 4.3	Trophic level 4.5	Trophic level 3.5	Trophic level 3.6

shrimps. Except for few months (October, November and December) the feeding intensity was found to be good throughout the year. Low feeding in these months may be associated with calving activity since *Neotrygon kuhlii*, *Rhinoptera javanica*, *Aetobatus narinari* and *Manta birostris* exhibit calving during the months of October to December. The litter size of *Neotrygon kuhlii*, *Rhinoptera javanica*, *Aetobatus narinari* and *Manta birostris* were 1-3, 1-2, 1-2 and 1 respectively.

Rays and guitarfishes: The length range of different rays/guitarfish species recorded at Mangalore were :

Rhinoptera javanica : 98 -100 (males& females)
Himantura gerradi : 28 - 73 cm (males) and 42 - 177 cm (females)
Pteroplatytrygon violacea : 41 cm (male) 33-50 cm (females)
Mobula japanica : 68 - 225 cm (males) and 46-233 (females)
Rhinobatos obtusus : 28 - 34 cm (males) and 87 cm (females)
Rhina ancylostoma : 58 cm (males) and 54 - 56 cm (females)

Taxonomy of *Neotrygon* species complex

Studies carried out with specimens collected from northern and southern Arabian Sea along the west coast, northern and southern Bay of Bengal along the east coast of India and Andaman Sea suggest that the *Neotrygon* species complex distributed in Indian waters comprises at least 3 distinct species.

Non-Detriment Findings

A Non-Detriment Findings study was carried out to assess the status of population of three hammerhead sharks, the oceanic whitetip shark and two manta rays in Indian waters since these species were brought under Appendix II of CITES in September 2013. The study showed that the stocks of hammerhead sharks and the oceanic whitetip shark are not currently under threat in Indian waters and therefore positive NDFs with management measures are recommended. Data however was insufficient to assess the status of manta rays and therefore the NDF study will be taken up again after three years during which period data collection will be strengthened with stakeholder participation. The results of the findings are being submitted to the MoEF & CC to enable management measures to regulate trade of these species in accordance to CITES regulations and in line with applicable rules of the Government of India.

Stakeholder consultations on Elasmobranchs at different centres

Stakeholders' consultations

The annual stakeholder consultations held at different centres of CMFRI were attended by fishers, fish farmers, representatives from various state and central government agencies, fishermen co-operative societies, fishermen associations, fishing industry and NGOs in addition to CMFRI officials.

Veraval

Elaborate discussions took place on the recommendations of the draft policy brief on marine fisheries such as, modernisation of token system; mesh size regulation; catch reporting; fishing area limitation; light fishing; line trawling; optimum fleet size; regulation in EEZ; sea

safety measures; monitoring, control and surveillance system; vessel monitoring system; value addition and amendment of Gujarat Fisheries Act 2003.

Mumbai

Issues discussed were, conservation of mangrove and marine mammals; demarcation of fishing areas for effective coastal zone management; climate change & fish landings; developmental issues like Shivaji statue, Bullet train project & ONGC drillings in coastal waters; Marine Fisheries Regulation Act of Maharashtra as well as new developments after its implementation. Points raised by stakeholders were extension of mechanised fishing ban by government orders; closed season to support revival of fishery; methods to reduce plastic in oceans and studies on impact of marine pollution on fishes. Increased occurrence of jelly fish along the Maharashtra coast and the need for investigations on the probable reasons and possibility of forecasting jellyfish swarming; marine mammal stranding its reasons and more training and support in cage culture activities were other researchable areas which were raised by the stakeholders.

Karwar

Stakeholders expressed their views on problems associated with shrimp farming such as disease outbreak; wave current and pollution caused by the Atomic Power plant which is causing problem for human as well as well as estuarine environmental health including the hazards caused to aquatic organisms like shellfish, finfish and shrimp farming. The stakeholders requested for consultancy services to the farmers of Uttara Kannada District regarding the water quality and health status as well as live feed. Majali was suggested as a possible site for cage culture. Initiatives to be taken by state government in order to promote cage culture in Uttara Kannada were also discussed. The work carried out by the state government of Goa in promoting cage culture by providing financial support was well appreciated during the meeting.

Vizhinjam

Stakeholders from the traditional sector opined that among the many sectors which depend on the ocean for their wealth, such as mining, ports, marine tourism; the fishery sector represented by the fisherfolk were benefitted the least. Representatives from the NGO 'Friends of Marine Life' expressed their view that the scientist-fisherfolk linkage need to be strengthened. Major recommendations raised were: ban on ringseine fishing practiced along Perumathurai and Marianadu; strict implementation of boat licensing and their registration; training on GPS to fishermen; pollution due to dumping of plastic wastes at sea and exploitation by middlemen in

Stakeholder meeting at Vizhinjam Centre

Stakeholder meeting at Tuticorin Centre

the marketing sector. Issue on lack of adequate facilities in fish markets was also discussed. Functioning of self-help groups in Thiruvananthapuram District was judged as poor and it was suggested that the groups should revitalise their activities focusing on economically viable income generating activities rather than resorting to credit mobilisation for availing personal loans.

Tuticorin

Concerns raised by stakeholders were: reduction of fish species like false trevally *Lactarius lactarius*, threadfins, pomfrets and ribbonfishes along Tuticorin coast and exploitation of juveniles especially undersized lobsters. Fishermen opined that indiscriminate collection of seeds were to be avoided along Gulf of Mannar coast and operation of destructive gear should be stopped to safeguard sessile benthic fauna for future. Trawl fishers expressed their willingness to convert their vessels to gillnetters with adequate government assistance. They also urged local authority to strictly implement the Marine Fishing Regulation Act effectively and to take action on fishermen operating banned destructive gears like ringseines and pair trawl. Introduction of satellite based fishing vessel monitoring system was suggested for the proper monitoring of fishing boats and also for the faster rescue of fishermen in distress. Further, the fishing vessel tracking system will enable the boats not to violate the International Maritime Border Line. Trawl fishers suggested that multiday deep sea fishing to be encouraged by providing adequate infrastructures like mother vessel in subsidised manner, in order to avoid the sectoral conflict between traditional and mechanised fishers and also to effectively harvest deep sea resources. Fishermen raised pollution as another issue causing loss of benthic fauna which needs to be curtailed. They also suggested that effective control to be imposed on the net manufacturers to ensure the mesh size as specified in Marine Fishing Regulation Act. Awareness and implementation on the use of cod end square mesh size and strict implementation of cod end mesh size need to be done.

Mandapam

Fishermen expressed their appreciation in the results of the research programmes of CMFRI and opined that sea ranching is very useful in replenishing the shrimp resources of the region. After the meeting, about 2 lakhs numbers of *Penaeus semisulcatus* seeds at PL 35 stage were released at Thonithurai in Palk Bay region.

Release of PL 35 stage of *Penaeus semisulcatus* at Thonithurai, Palk Bay

Chennai

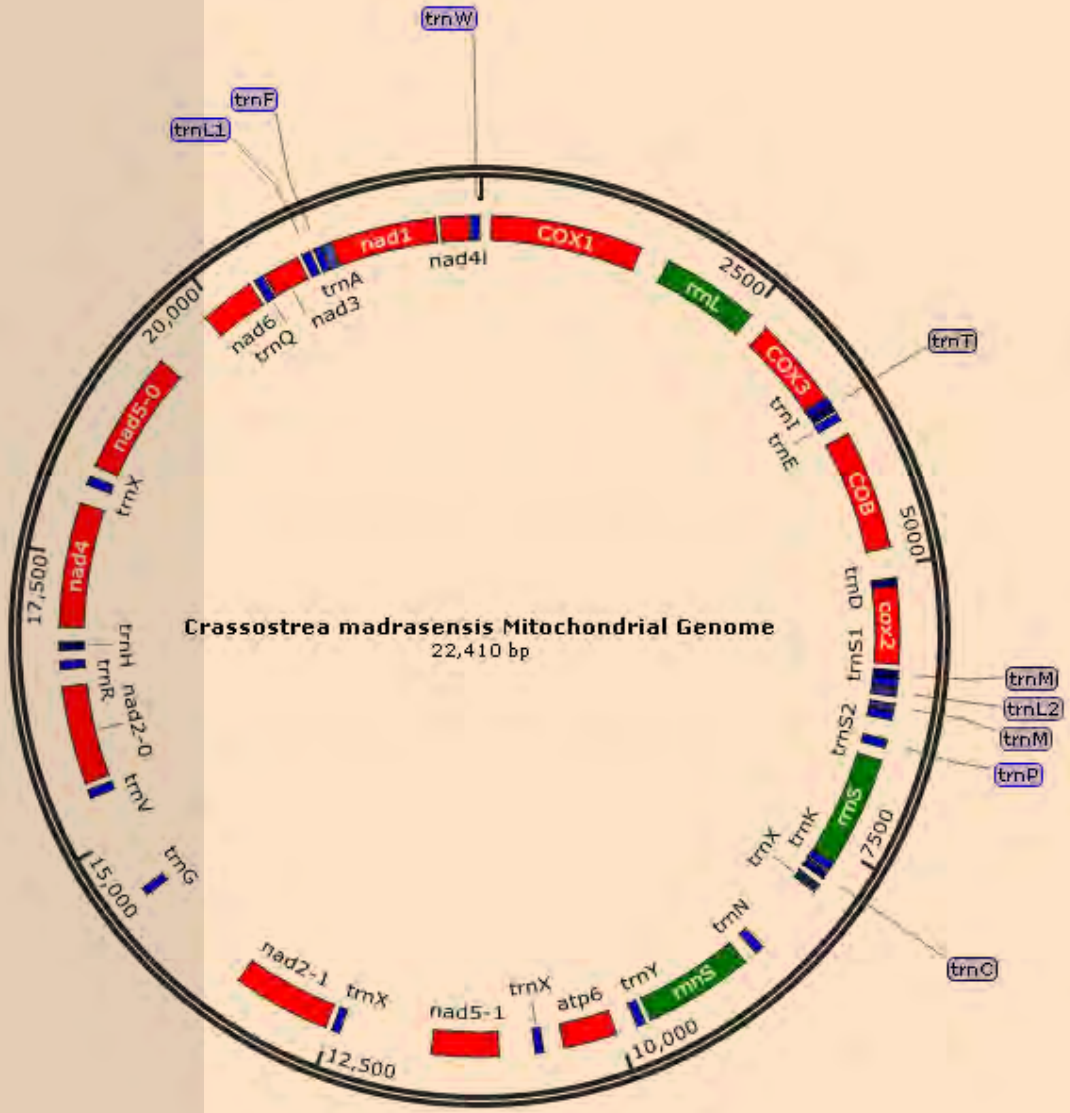
The meeting was conducted at the office of the Chennai Fishing Management Committee Office, Royapuram. Discussions ensuing presentation of the status of Tamil Nadu fishery brought out the following points from the fishermen: need for introduction of uniformity in the size of boats, engine power and net; effective implementation of ban on ringnet and pair trawl without leaving it to the discretion of fishermen and sufficient representation of fishermen in the committees constituted in fisheries sector.

Visakapatnam

The following researchable issues and management initiatives were identified from the discussions: addressing the impacts of coastal pollution on marine biodiversity and fishery health; mapping of zones of critical importance to fisheries of Visakhapatnam District with special emphasis on breeding grounds and feeding grounds; impact of broodstock collection on wild stock of *Penaeus monodon*; survey to check for incidental invasion of *Penaeus vannamei* in to the wild; addressing the potential for artificial reef deployment along sensitive areas of the coast; survey of plastic pollution in the coastal areas of Visakhapatnam; reduction of bycatch and juvenile catch in trawlnets; sea ranching as a means of increasing marine biodiversity and production; collaborative research efforts between CMFRI and CIFT with respect to trawl mesh size studies and GIS-based studies; importance and critical relevance of co-management *i.e.,* management of the resources by the fishermen themselves with assistance from central and state agencies; restriction of fleet size to the optimum level; diversification of fishing effort to target tuna resources; uniform fishing ban for all fishing sectors in the state; use of 40 mm square mesh size for trawl cod end to reduce bycatch and juvenile catch; innovative methods to reduce plastic pollution in the sea; compulsory inclusion of CMFRI and CIFT in EIA studies of coastal industries in the state; overhaul of the fish marketing facilities and infrastructure of the state; development of major fishing harbours as model fishing harbours, particularly Visakhapatnam and Kakinada

Stakeholder consultations on Elasmobranchs

A series of stakeholder consultations were held at different centres along the Indian coast (Tuticorin, Mumbai, Chennai, Mandapam, Veraval, Mangalore, Kochi and Thuthoor) during August-September 2016 to discuss results of the NDF study and to invite stakeholder participation in formulating management measures for sustainable exploitation and conservation of India's elasmobranch resources. One of the major outcomes of these stakeholder consultations was the consensus for creating a common data sharing platform through which stakeholders can upload valuable fishing and trade data, which will increase the validity of data collected by CMFRI and help in better assessment of stock status.

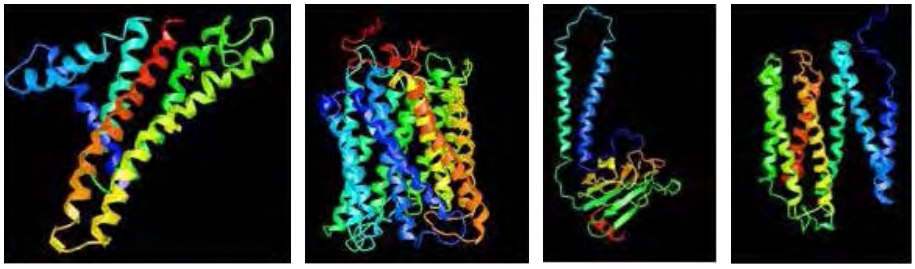


Genetics and genomics

Complete mitochondrial sequence of *Crassostrea madrasensis*

Research Project: FISHCMFRISIL2012022800028

The complete mitogenome of the Indian oyster, *Crassostrea madrasensis* was characterised. The whole mitogenome is 22,410 bp in size and codes for 14 functional proteins. The genome also possesses several unique features of *Crassostrea* sp. such as absence of ATPase 8, duplication of rRNA, and presence of additional tRNA K and tRNA Q.



ATP6 protein COI COII COIII

Mitogenomic approach to study environmental adaptation in *Sardinella longiceps*

The response to fluctuations in environmental conditions was studied in Indian oil sardine, *Sardinella longiceps* using whole mitogenome scans. The complete mitogenomes of 45 sardines collected across the range of distribution mainly North West, South West and South East Indian ocean were characterised and analysed to understand mitogenome level variations. Evidence for positive and diversifying selection was found on OXPHOS genes mainly ATP6, CO1, CO2, CO3, Cyt b, ND1, ND2, ND4 and ND5. Differentially selected ecotypes were found in sympatry in all these locations supporting the conclusion that metabolic divergence is a critical adaptation involved in Indian oil sardine sub population structuring.

Population genetic structure of Indian anchovy, *Stolephorus indicus* studied using mitochondrial DNA markers

Population genetic structure of the Indian anchovy, *Stolephorus indicus* was studied using mitochondrial ATPase and COI sequences. *S. indicus* was collected from Vizag, Tuticorin, Cochin, Goa and Andamans. ATPase and Cytochrome C Oxidase 1 sequences were amplified in 90 and 105 individuals respectively. High haplotype diversity was associated with low nucleotide diversity in both sets of sequences. There were 44 haplotypes out of 90 individuals with a haplotype diversity value of 0.82 and nucleotide diversity value of 0.002 when ATPase sequences were analysed. The sequences of Cytochrome C oxidase revealed 52 haplotypes out of 105 individuals with a haplotype diversity value of 0.651 and nucleotide diversity value of 0.002. The highest haplotype diversity was observed in samples from Vizag (0.93) and lowest in samples from Kochi (0.49) when COI sequences were analysed. ATPase gene sequences from Turicorin showed highest haplotype diversity (0.96) while that of Andaman showed the lowest nucleotide diversity (0.60). Overall genetic differentiation was low and insignificant between populations indicating panmixia.

Microsatellite marker development in *Eleutheronema tetradactylum* using Next Generation Sequencing Technology

Research Project: EFP-14

Three *Eleutheronema tetradactylum* samples from Kerala were collected and labeled KET25, KET29 and KET30 and microsatellite markers were developed through Next Generation Sequencing Technology. Whole genome sequencing was performed on KET25, KET29 and KET30 using Illumina Nextseq500 platform using 2 x150bp chemistry. After trimming low quality reads and adapter sequence, high quality reads were used to carry out Denovo assembly and the potential SSRs were detected using microsatellite identification tool (MISA v1.0). The potential SSRs were identified as ranging from dinucleotide motifs with a minimum of 10 repeats, tetra, penta, and hexa nucleotide motifs with a minimum of 5 repeats. A maximum distance of 200 nucleotides was allowed between two SSRs. Among 289,461 scaffold sequences examined in KET25 sample, 60,246 SSRs were identified. In KET29 sample, out of 280,260 scaffolds examined, 46,107 SSRs were identified. Similarly in KET30 sample, out of 289,650 scaffolds examined, 60,904 SSRs were identified. Finally 23,983, 17,693 and 24,033 validated SSRs based on flanking sequence for KET25, KET29 and KET30 samples respectively were obtained.

Indian salmon-*Eleutheronema tetradactylum*

From the SSRs identified through the NGS technology, we have designed and developed 100 polymorphic microsatellite markers with di, tri, and tetra nucleotide repeat. Out of the 100 markers developed through NGS, 50 microsatellites were synthesised and initial screening is in progress.

Population genetic structure of *Lutjanus argentimaculatus* using microsatellite markers.

Genetic stock structure of *L. argentimaculatus* was studied using microsatellite markers by collecting samples from Mumbai, Mangalore, Kochi, Mandapam, Vizag and Port Blair. Twelve polymorphic microsatellite markers were identified through cross species amplification. Repeat motif in candidate species was confirmed through sequencing and the sequences submitted to NCBI. Microsatellite genotyping was carried using 6FAM labeled primers. A total of 331 samples were genotyped from six different locations using 9 microsatellite loci. Number of alleles ranged from 19 to 70, allele size ranged from 100 to 348, Ho values ranged from 0.526 to 0.918, and the He values ranged from 0.693 to 0.918. Microsatellite genotyping using 9 microsatellite primers has been completed and the remaining is in progress.

Molecular taxonomic studies on *Paphia malabarica* from Indian coast

Research Project: FISHCMFRISIL2012022800028

Paphia malabarica

Paphia malabarica from Indian waters was collected and studied to ascertain their taxonomic identity using Cytochrome C Oxidase 1 and 16S rRNA sequences. *P. malabarica* has been synonymised as *Protapes gallus* recently. Samples were collected from Kollam, Calicut, Dharmadam, Kasargod and Tuticorin to ascertain their species identity. Analysis of *P. malabarica* sequences from Indian coast revealed that they are genetically different from *P. gallus*.

Forensic identification of stranded Cetaceans

Forensic identification using molecular markers was carried out on stranded cetaceans from Mumbai coast. DNA was extracted from skin tissue preserved in salt. Cytochrome C Oxidase 1 gene was amplified and sequenced using universal primers. The specimens were identified as belonging to *Balaenoptera edeni*, *Neophocaena asiaorientalis asiaorientalis* and *Sousa chinensis*.

Molecular taxonomy of *Gymnura poecilura*

Ambiguity in species identification of *Gymnura poecilura* from Indian waters was cleared using Cytochrome C Oxidase and NADH2 genes. A 650-bp region of the Cytochrome C oxidase 1 was amplified using a universal primer in specimens from Visakhapatnam (10), Veraval (2) and Mumbai (2), and NADH2 genes were amplified from specimens collected at Visakhapatnam (5), Mumbai (2) and Veraval (2). The sequences of Cytochrome C Oxidase 1 (COI) (593 bases) and NADH2 (640 bases) of *G. poecilura* and *G. cf. poecilura* collected from north-west coast of India (Veraval and Mumbai) were aligned with sequences retrieved

from GenBank of other valid species of *Gymnura* using Clustal W in MEGA 6. A phylogenetic tree was constructed using UPGMA method with 1000 bootstraps. Genetic divergence between all the species was analysed using Kimura 2 p distance values in MEGA 6. The phylogenetic tree constructed using 30 sequences of COI of *G. poecilura*, *Gymnura* sp. A and *G. cf. poecilura* and 14 sequences of NADH2 of *G. poecilura*, *G. cf. poecilura* and *Aetoplatea zonura* showed distinct clustering among species with significant bootstrap values. In the COI tree, *G. poecilura* sequences of the topotype specimens from Visakhapatnam (KU661963-KU661972) clustered together with *G. poecilura* from Jakarta Raya, Indonesia (EU398804), *G. poecilura* from Haikou, Hainan Province of China, *G. poecilura* from Kakinada (JX978320- JX978324) and *G. poecilura* (KF899447-KF899450) collected from Kollam along south-west coast of India. However, *G. cf. poecilura* in this study from Veraval and Mumbai (KU821573-KU821576) and sequences described as *Gymnura* sp. A (KF899442- KF899446) collected from Mumbai clustered separately from the first clade with significant bootstrap values indicating that these sequences belong to a different species. The genetic divergence between these two clades was 13.6% (K2P distance) ascertaining these conclusions. Similar conclusions were also derived from the NADH2 tree as ND2 sequences of the topotype specimens from Visakhapatnam (KU821581-KU821585) clustered together with ND2 sequence of *G. cf. poecilura* (JQ519068) from Kalimantan, Indonesia, confirming that it is *G. poecilura*, while ND2 sequences of *G. cf. poecilura* from Veraval and Mumbai (KU821577-KU821580) clustered together with *G. cf. poecilura* from Oman waters (JQ518834) (northern Arabian Sea), pointing to their separate species identities.

Molecular taxonomy of *Scomber indicus*, a new species of mackerel from Eastern Arabian sea

Molecular taxonomic studies were carried out in the new species of mackerel, *Scomber indicus* collected from Eastern Arabian sea using Cytochrome C Oxidase 1 and cytochrome b genes. The phylogenetic tree constructed using 31 sequences of CO1 and 35 sequences of cytochrome b of the five *Scomber* species including *S. indicus* sp. nov. showed distinct clustering among species with significant bootstrap values. Within species, Kimura 2 parameter (K2P) distance values for CO1 varied between 0.2-0.8% among the four valid species of *Scomber*. K2P distance percentage values between species for CO1 showed 2.2, 1.8, 1.4 and 10% divergence between *S. indicus* sp. nov. and *S. australasicus*, *S. japonicus*, *S. colias* and *S. scombrus* respectively. Significant divergence was also observed in cytochrome b gene sequences between *S. indicus* sp. nov. and other valid species of *Scomber*. The K2P values for cytochrome b showed 4.4, 3.8, 3.4 and 18.2% divergence between *S. indicus* sp. nov. and *S. australasicus*, *S. japonicus*, *S. colias* and *S. scombrus* respectively. Genetically, the new species is closest to *S. colias* followed by *S. japonicus*.

Molecular basis of osmoregulation in sand lobsters exposed to different abiotic factors

The molecular basis for tolerance to abiotic stress is being studied in the Sand Lobster, *Thenus unimaculatus*. The animals were exposed to low (16ppt) and high (48ppt) salinities and compared with a control group (32ppt, normal salinity). Hepato-pancreas and abdominal muscle were collected at two different time points post treatment (1 and 2 hours). The collected tissues were stabilised in RNA Later solution until further downstream processing and total RNA extracted from hepato-pancreas and abdominal muscles. The extracted RNA was converted to first strand cDNA which could be used for further amplification. Three sets of primers were synthesised for studying the pattern of gene expression of heat shock proteins (HSP 70F/HSP 70R, HSP90 1F/1R, HSP90 2F/2R) and one for housekeeping gene Actin (ACT F/R). The variations in the expression pattern of heat shock protein genes in sand lobsters exposed to abiotic stress on real time basis is being carried out using TaqMan and SYBR green dye assay.

Development and testing of species-specific mitochondrial DNA markers for larval identification of commercially important spiny lobster species and testing their efficiency in larvae.

Successful captive hatching of four species of spiny lobster brooders (*Panulirus homarus*, *P. versicolor*, *P. ornatus*, *P. longipes longipes*) and captive breeding of *P. polyphagus* were achieved at Mandapam RC during Nov 2015 to March 2016 & in Dec 2016 for conducting molecular studies in phyllosoma larvae. Developed a common set of primers for amplification of 800 bp control region of mitochondrial DNA in six commercially important spiny lobsters (Family: Palinuridae) available along Indian coast. Efficiency of primer pair was tested by PCR amplification & sequencing in individual species and larvae.

Biofouling and comparative phylogeographic status of the barnacle *Chelonibia testudinaria* on various hosts from the Gulf of Mannar

Genetic identity of the crab barnacle (*Chelonibia patula*) from live broodstock of various commercially important crustacean hosts (*Panulirus polyphagus*, *Portunus pelagicus* and *Charybdis natator*) was assessed with mitochondrial CO1 gene and compared with that of turtle barnacle (*C. testudinaria*) from olive ridley (*Lepidochelys olivacea*). The low genetic distance (K2P-0.007) between the two barnacle species together with available GenBank records showed that both of them represent the same species of *Chelonibia* which should be synonymised under the more senior Linnaean epithet *testudinaria* as suggested by other workers (Cheang *et al*., 2013; Zardus *et al*., 2014). The morphological variation between the two is a case of host-specific phenotypic plasticity. The barnacles of genus *Chelonibia* from the Southeast coast of India belonged to the Indian Ocean/ Western Pacific clade of *C. testudinaria / C. patula* complex on phylogeographic comparison.

Phylogenetics & evolution of bioluminescent organ systems in the ponyfishes (Family: Leiognathidae) from Indian coast.

Twenty species of Leiognathids were collected from Indian coast and their identity was confirmed by morphological examination and molecular methods. Species revision was done as per latest references on ponyfish taxonomy (Sparks & Chakrabarty 2015; Chakrabarty & Sparks 2015). Sequencing of the three mtDNA markers and nuclear EPIC marker were completed and sequences of all species submitted to GenBank. Ancestral character state reconstruction and phylogenetic analysis are under progress.

Diet analysis using molecular markers in commercially important tunas

Research Project: EFP-21

The food components of commercially important tunas, Mackerel tuna, *Euthynnus affinis*, Skipjack tuna, *Katsuwonus pelamis* and yellowfin tuna, *Thunnus albacares* were assessed using molecular markers. One hundred and eighty five guts were analysed in *E. affinis* for diet studies. *E. affinis* specimens were grouped to different size classes; size class 1 (150-350mm standard length), size class 2 (350-550mm standard length) and size class 3 (550-750mm standard length) and the dominant food item based on frequency of occurrence was ascertained. Fin fishes formed the most dominant food item in mackerel tuna. A total 24 different prey items were recovered from the gut of mackerel tuna indicating good prey diversity. Sixty guts were analysed in *K. pelamis* for diet studies. *K. pelamis* specimens were grouped to different size classes; size class 1 (300-450mm standard length), size class 2 (450-600mm standard length) and size class 3 (600-750mm standard length) and the dominant food item based on frequency of occurrence was ascertained. The study showed that in size class one, dominant food item consists of crustaceans, followed by squids, fishes and amphipods. As tunas grow in size, they become more piscivorous. Sixty guts

were analysed in *T. albacares* to ascertain the diet status. *T. albacares* specimens were grouped to different size classes; size class 1 (350-750mm standard length), size class 2 (750-1150mm standard length) and size class 3 (1150-1550mm standard length) and the dominant food item based on frequency of occurrence was ascertained. The results indicated substantial consumption of fishes by yellowfin tuna. Cannibalism has also been indicated in yellow fin tuna.

Characterisation of Hepcidin, a cysteine rich anti-microbial peptide from fishes

Hepcidin, a cysteine rich anti-microbial peptide with multiple isoforms in fishes with important role in immune defense was characterised in grouper, *Epinephelus diacanthus*. The complete ORF of Hepcidin was amplified which consisted of three exons and two introns. The 270 bp ORF coding for a micro peptide with 89 amino sequences have shown 10 base substitutions between related fish species.

Characterisation of genes related to growth and metabolism from marine food fishes

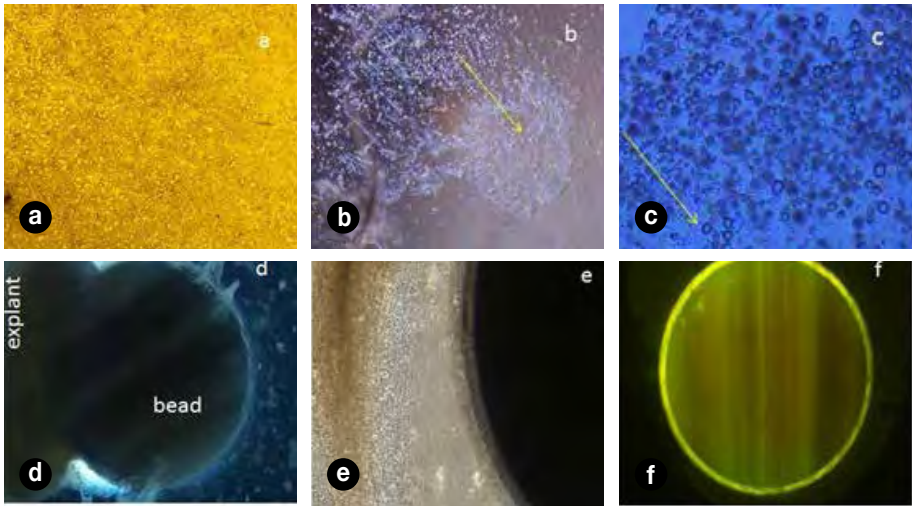
Research Project: FISHCMFRISIL201202700027

Genes related to growth and metabolism were amplified and characterised in silver pompano, *Trachinotus blochii* and red snapper, *Lutjanus argentimaculatus*. Muscle, liver and stomach tissues were collected, RNA isolated, and converted to cDNA using standard protocols. PCR amplification of the genes of interest was carried out using specific primers, amplified product was eluted, cloned and sequenced. The sequences were submitted to NCBI, GenBank with the following accession numbers;
Lutjanus argentimaculatus Leptin gene Accession No: KY209926
Trachinotus blochii Galanin gene Accession No: KY209927
Trachinotus blochii Leptin gene Accession No: KY209928
Further, expression studies could be carried out on these genes with respect to different nutritional conditions.

Development of tissue culture technology for *in vitro* production of pearls from the black-lip pearl oyster *Pinctada margaritifera* and refinement of *in vitro* pearl formation in *Pinctada fucata*

Research project: FISHCMFRISIL201202900029

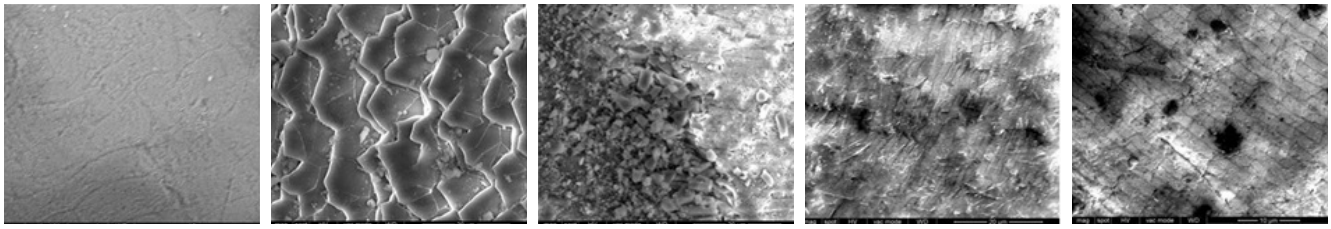
Characterisation of natural pearl was done as a model for reference to the cultured and *in-vitro*



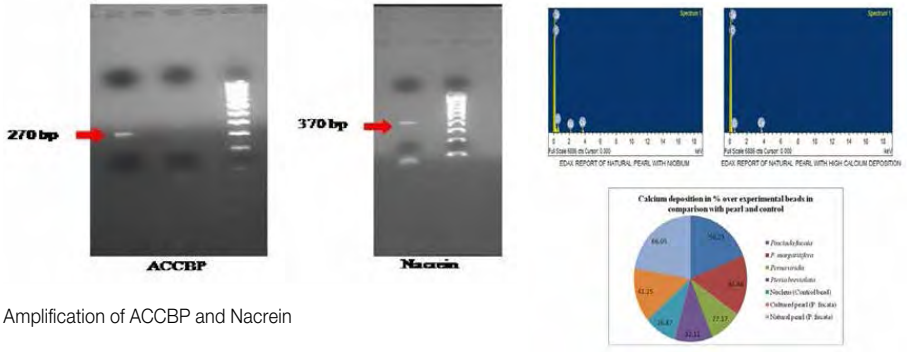
Different stages of *in vitro* nacreinformation in *Pinctada fucata.* a. cell sheet formed in culture vessel. b. matrix formation. c. Mature granulated epithelial cells liberating nacre crystals. d. pearl sac formation over the bead. e. pearlsacof epithelial cells on one side of the bead in higher magnification. f. nacre formation over bead with free epithelial cells

Nacre deposition on bead nucleus observed under a stereo microscope at different intervals after incubation with cultured granulated mantle epithelial cells. a. 0 day, b. 7 days, c. 15 days, d. 30 days, e. 60 days, scale bar 200µm.

pearls. Calcium deposition in *in-vitro* pearls from *P. fucata* and *P. margaritifera* was higher than in cultured pearl and lesser than in natural pearl. A new element Niobium identified in the natural pearl gives us an insight into the nacre studies for development of a lustrous pearl. Niobium is an element with lustrous properties. Methyl mandelic acid extracted from *Isochrysis galbana* is also being used as a supplement in tissue culture medium for biomineralisation studies. Induction of nacre coating over the beads using mantle tissue of different pearl producing molluscs proved that this technology is feasible for *in-vitro* nacre formation and biomineralisation.



Scanning electon microscope images of nuclear bead surface at different intervals after incubation with cultured granulated mantle epithelial cells. a. 0 day (control), b. 7 days, c. 15 days, d. 30 days, e. 60 days



Amplification of ACCBP and Nacrein

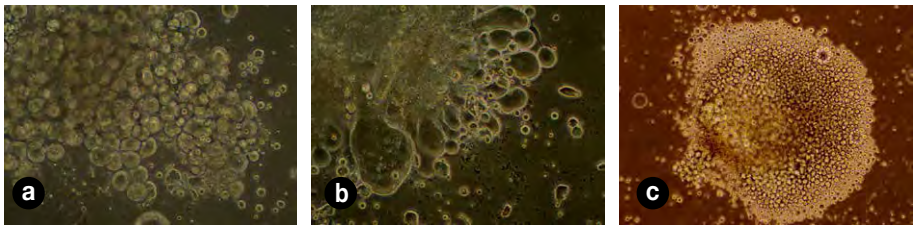
A protocol for inducing nacre layer formation on nuclear beads under *in vitro* conditions using cultured granulated epithelial cells from mantle tissue of black-lip pearl oyster *P. margaritifera* was developed. A visual change in coloration on the surface of the bead to a dull brown could be noticed after about 14 days of incubation. Stereomicroscope observations at periodic intervals showed gradual formation of blackish yellow coloured nacre deposits on the surface of the beads, similar to the processes observed during pearl formation under *in vivo* conditions. Scanning electron microscopy showed an irregular pattern of $CaCO_3$ deposition in the initial stage and a typical brick and mortar formation characteristic of nacre, at all later stages. Energy dispersive X-ray analysis of these stages showed calcium, carbon and oxygen as the prominent peaks in the spectra. Cryopreservation of cultured granulated mantle epithelial cells was carried out using different concentrations (5-10%) of glycerol and dimethyl sulfoxide as cryoprotectants. Best cryoprotective effect was provided by 10% glycerol. Nacre secretion *in vitro* by granulated epithelial cells in culture was confirmed by detecting gene expression of two matrix proteins namely nacrein and amorphous calcium carbonate binding protein, in cultured cells.

Stem cell culture

Research project: FISHCMFRISIL201203100031

Derivation of embryonic stem cell cultures (EScs)

Embryonic stem (ES) cell cultures derived from midblastula stage embryos of *Amphiprion ocellaris* and *Premnas biaculeatus* were cultured in DMEM/F12 medium supplemented with foetal bovine serum, 2 mM non-essential amino acids, 2 mM L-glutamine, 50 µg ml^{-1} Pen-Strep, 0.1 mM β-mercaptoethanol and 4 ng ml^{-1} of bFGF. ES colonies derived were detached using dispase treatment for subculture and passaging to derive continuous ES cell lines. The ES cultures derived have been characterised for stem cell specific markers.



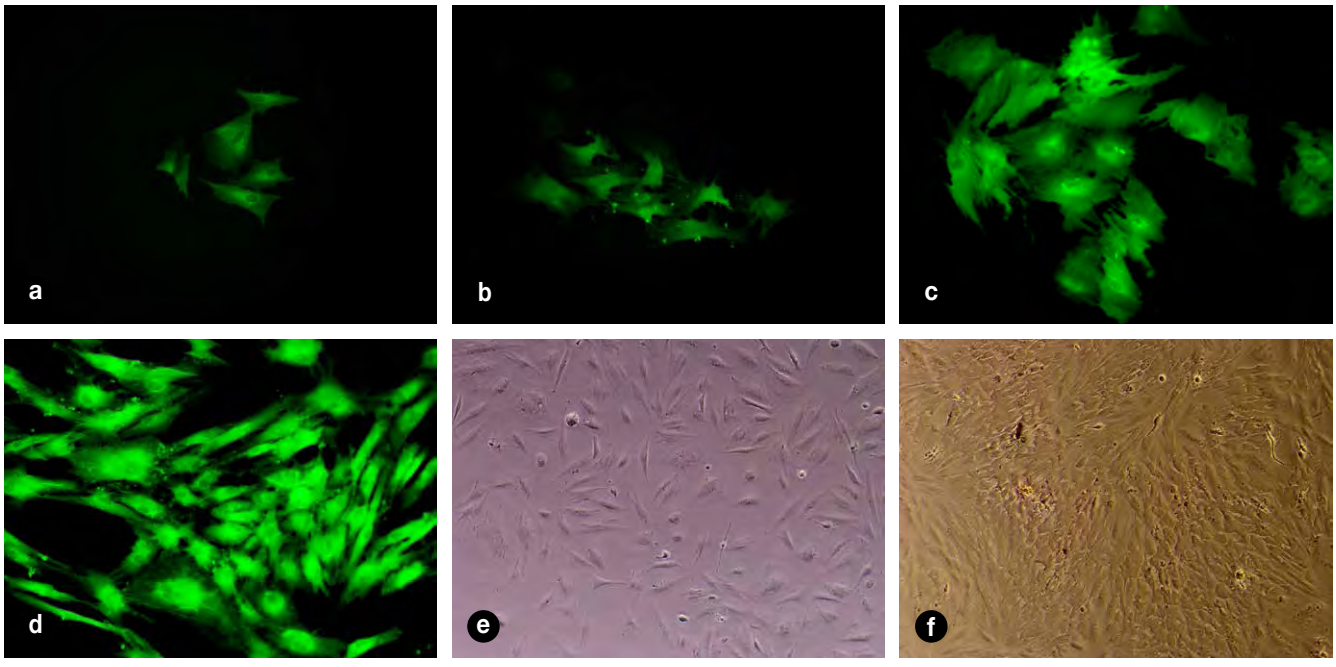
ES cell cultures from *P. biaculeatus* embryos

Derivation of induced pluripotent stem cell cultures (iPScs)

Research project: EFP-23

For derivation of induced pluripotent stem cell cultures (iPScs), the cell culture system CA1F4Tr initiated from fin tissue of *Cromileptes altivelis* at passage level 3 was transfected with the oriP/EBNA1 episomal vector pEP4 E02S CK2M EN2L having 6 pluripotentcy transcription factors *viz.,* Oct4, Sox2, Nanog, Klf4, Lin28 and C-Myc, by Nucleofection, along with pMAX GFP as positive control vector. Strong signals of GFP expression by fluorescence microscopy as well as formation of putative iPS colonies by phase contrast microscopy were recorded. The effect of different types of pathway inhibitors and supplements are being evaluated for improving reprogramming efficiency.

Fluorescence images of CA1F4Tr a. day 4, b. day 6, c. day 20, d. day 36 post-transfection Phase contrast images of CA1F4Tr e. day 1, f. day 36 post-transfection



Fish nutrition

Growth and body composition of Silver Pompano, *Trachinotus blochii* (Lacepede, 1801) reared in low saline water in response to different levels of dietary lipids

Research Project: FISHCMFRISIL201202700027

An experiment to delineate the gross fat requirement of silver pompano was conducted for a period of 75 days in 18 numbers of square glass aquaria (60 × 60 × 50 cm, 180 L capacity). One hundred and forty four fingerlings with an average bodyweight of 6-7 g, acclimatised to 5 ‰ salinity were randomly distributed in six treatments and fed with slow sinking formulated

feeds containing 4%, 5%, 6%, 7%, 8% and 9% crude lipid and constant level of crude protein (42%) in all diets.

The results of the present study indicated that percentage weight gain (WG%), Specific Growth Rate (SGR), Protein Efficiency Ratio (PER), Feed Efficiency Ratio (FER) and Feed Conversion Ratio (FCR) were not significantly different among the treatments. However, maximum WG% and SGR was noticed in 7% group and the least value was observed in 5% group. In case of PER and FER, the maximum efficiency was witnessed in 9% group and least efficiency in 4% group. The FCR was in the range of 1.70-1.83 in different treatments.

Growth indices of Silver pompano fed with experimental diets

Growth parameters	4%	5%	6%	7%	8%	9%
WG (%)	886.90 ±28.5	856.7 ±22.2	888.4 ±58.9	895.10 ± 48.8	869.9 ± 10.9	884.2 ± 41.0
SGR (%)	3.05 ±0.04	3.01 ± 0.03	3.04 ± 0.12	3.06 ± 0.06	3.03 ± 0.01	3.05 ± 0.06
FCR	1.83 ± 0.03	1.79 ± 0.10	1.80 ± 0.10	1.74 ± 0.04	1.74 ± 0.07	1.70 ± 0.02
PER	1.17 ± 0.02	1.20 ± 0.07	1.19 ± 0.08	1.23 ± 0.03	1.23 ± 0.05	1.25 ± 0.02
FER	0.49 ± 0.01	0.50 ± 0.03	0.50 ± 0.03	0.52 ± 0.01	0.52 ± 0.02	0.50 ± 0.01
ADG (g)	0.75 ± 0.03	0.71 ± 0.02	0.75 ± 0.07	0. 73 ± 0.03	0.73 ± 0.01	0.73 ± 0.04

WG (%)-Weight gain %; SGR (%)- Specific growth rate (%); FCR- Feed conversion ratio; PER- Protein Efficiency ratio; FER-Feed Efficiency Ratio; ADG (g)- Average daily growth in grams;

Data expressed as Mean ± SE n=3

Whole body Proximate composition

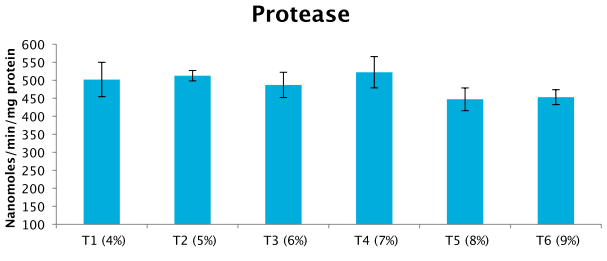
Whole body crude fat and crude protein contents of experimental fishes were significantly ($P<0.05$) influenced by different levels of dietary lipids. Higher level of crude fat was observed in 9% group and lower level in 4% group. Higher level of crude protein content was observed in 5% crude fat fed groups and lower level was witnessed in 9% crude fat fed groups.

Whole body proximate composition of experimental fishes fed with different level of dietary lipids

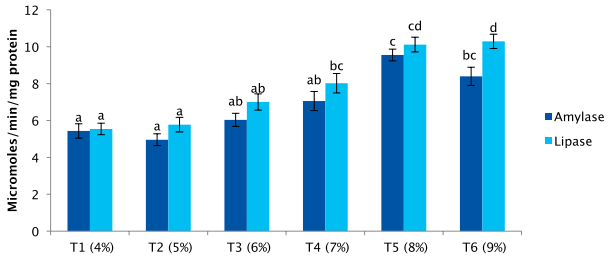
Treatment	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Total Ash (%)	NFE (%)
4%	64.08 ±1.32^{b}	28.01 ±1.30^{ab}	0.38 ±0.02	6.64 ± 0.63	0.88 ± 0.04
5%	65.77 ±0.76^{b}	26.78 ± 0.87^{a}	0.42 ± 0.01	6.43 ± 0.29	0.58 ± 0.03
6%	64.37± 1.80^{b}	27.93 ± 0.83^{ab}	0.4 0 ± 0.03	6.54 ± 0.45	0.75 ± 0.07
7%	64.47 ± 1.12^{b}	28.75 ±0.78^{ab}	0.39 ± 0.01	5.62 ± 0.33	0.75 ± 0.05
8%	61.96 ± 1.07^{ab}	30.39 ± 0.58^{b}	0.35 ± 0.02	6.33 ± 0.41	0.95 ± 0.06
9%	59.19 ± 1.45^{a}	33.56 ± 0.23^{c}	0.34 ± 0.02	5.69 ± 0.23	1.21 ± 0.09
P Value	0.041	0.001	0.065	0.973	0.814

Mean values in the same column with different superscript differ significantly ($P<0.05$).W

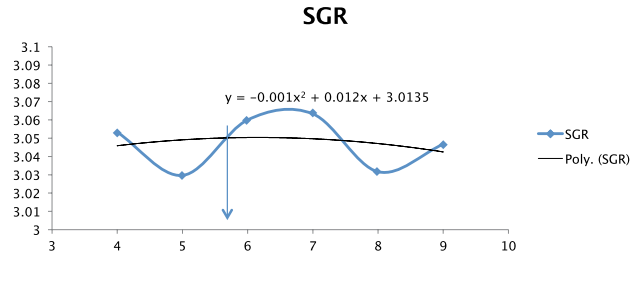
Data expressed as Mean ± SE n=3

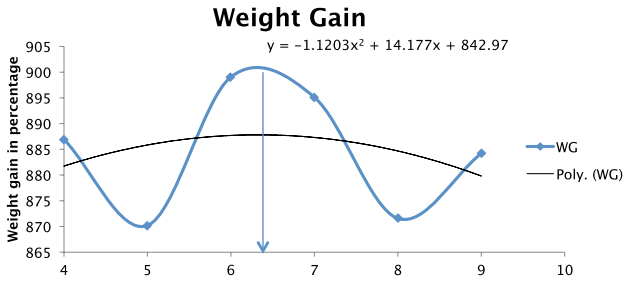


Protease activity of silver pompano fed with different level of dietary lipids
Data expressed as Mean ± SE n=3



Amylase and lipase activity of silver pompano fed with different level of dietary lipids. Data expressed as Mean ± SE n=3. Mean values in the bars with different superscript differ significantly ($P<0.05$).





Second degree polynomial regression analysis of SGR and WG (%) of silver pompano fed with different level of dietary lipids

Digestive enzyme activity

There was a significant difference in intestinal amylase and lipase activity ($P<0.05$). There was no significant difference in intestinal protease activity ($P>0.05$). Maximum intestinal protease activity was noticed in 7% group and the least activity was in 8% crude fat fed group.

After analyzing all parameters related to growth, based on the polynomial regression analysis of SGR and WG (%), the dietary lipid content within the range of 6.00-6.38% is adequate for the optimal growth of juvenile silver pompano.

In vitro antibacterial activity of *Fucoidan*

Bacteria	*Vibrio parahaemolyticus*		*Aeromonas hydrophila*	
Seaweed extract	MIC (µg/ml)	MBC (µg/ml)	MIC (µg/ml)	MBC (µg/ml)
Fucoidan rich seaweed extract	12.25	12.25	6.15	25.00

Immunomodulation of cobia (*Rachycentron canadum*) fingerlings through dietary intervention of brown seaweed extract, fucoidan

Fucoidan, a sulphated polysaccharide extracted from brown seaweed contains substantial amount of L-fucose which is reported to be a potential immunostimulant. *In-vitro* antibacterial activity and immunomodulatory effect of fucoidan was studied in cobia fingerlings.

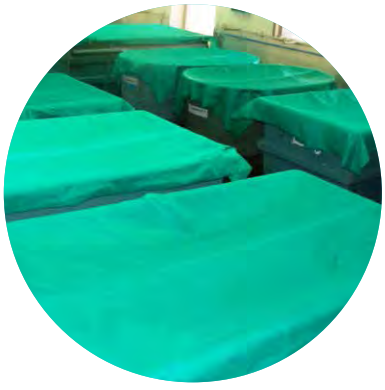
The Minimum Inhibitory Concentration (MIC) and Minimum Bacterial Concentration (MBC) of fucoidan were tested against pathogenic bacteria to assess the antibacterial activity of fucoidan. Fucoidan extracts show better MIC and MBC against gram negative bacterial strains *Vibrio parahaemolyticus* and *Aeromonas hydrophila.* The in-vitro antibacterial test shows that fucoidan extracted from brown seaweeds possess potential antibacterial activity and it could be used as a natural source of immunostimulants in fish feeds.

In-vivo immunomodulatory effect of crude fucoidan in cobia

Fucoidan was extracted from Indian brown seaweed *Sargassum wightii.* Four experimental feeds were prepared and designated C (diet without fucoidan), T1 (diet with 0.5 % fucoidan), T2 (diet with 1.0% fucoidan) and T3 (diet with 1.5 % fucoidan). Cobia fingerlings with an average weight of 15±2 g were randomly distributed in four treatments with triplicate. The fish were fed to apparent satiation twice daily (10:00 and 16:00 hrs) and experiment was conducted for 30 days. At the end of the experiment, blood and serum samples were collected from experimental animal for analysing immunological parameters. After this, fish from each treatment group were challenged with 0.1 mL of virulent *V. parahaemolyticus* suspension at a concentration

Experimental animal= Cobia

Blood collection



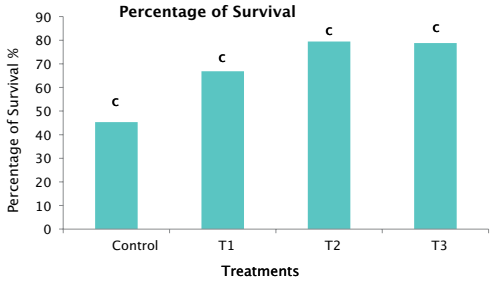
Experimental Setup

of 10^7 CFU mL^{-1} and survival was observed for 7 days. Then, post challenge sampling was performed for blood and serum samples.

The results of the present study revealed that there was significant difference ($p < 0.05$) in total serum protein, albumin(A), globulin (G) and A:G ratio among treatment groups in both pre and post challenge. Highest value was observed in treatment group and lowest was observed in control group. Serum ACP (Acid phosphatase) and ALP (Alkaline phosphatase) differed significantly between treatments and highest activity of ACP and ALP was found in control group and lowest was observed in T2 and T3 groups. ALP and ACP activity decreased with increasing immunostimulant levels in the diet. The NBT (Nitroblue tetrazolium) activity of different treatment groups showed increasing trend in both pre- and post-challenge conditions. The highest NBT value was found in T2 and T3 groups and lowest value was observed in control

Cumulative mortality (%) and percentage of survival (%) of different experimental groups challenged with *V. parahaemolyticus*

Treatment	Cumulative mortality (%)	Percentage of Survival (%)
Control	54.70	45.30
T1(0.5%)	33.14	66.86
T2(1%)	20.56	79.44
T3(1.5%)	21.20	78.80



Percentage of survival in different experimental groups challenged with *V. parahaemolyticus*

and T1 groups. Lysozyme and phagocytic activity define the first line defence mechanism in biological system. The respiratory burst, lysozyme and phagocytic activity of different treatments were significantly different ($P<0.05$) among themselves in both pre and post-challenge. The maximum and minimum value of respiratory burst, lysozyme and phagocytic activities were observed in T3 and Control group respectively.

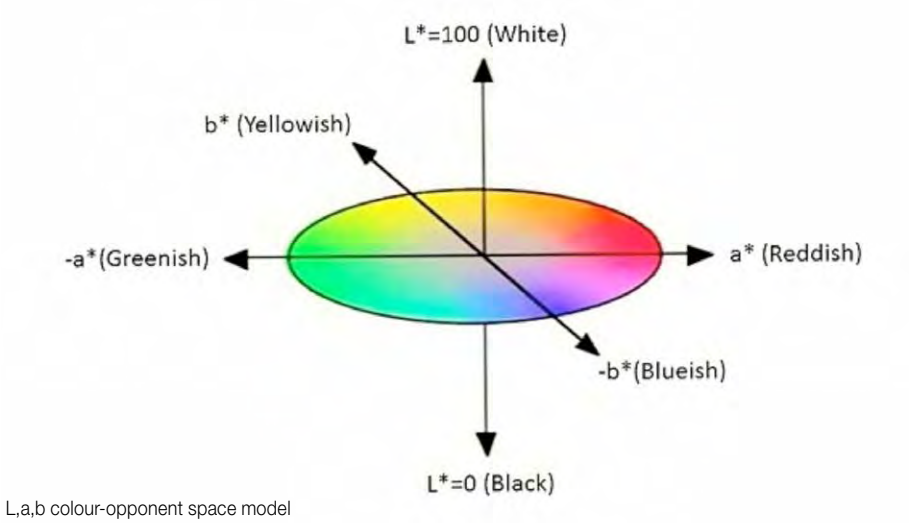
There was significant difference ($p < 0.05$) in cumulative mortality (%) and percentage of survival (%) between control and treatment groups when challenged with *V. parahaemolyticus*. The least survival was recorded in control group and highest survival was recorded in T2 and T3 groups. Overall, the study demonstrated that use of fucoidan in the diet of cobia can promote disease resistance capability against *V. parahaemolyticus* and provide a tonic to improve the immune system of the animal.

Enhancement of colour and growth in the marine ornamental fish, *Amphiprion ocellaris* through dietary administration of pigments

An experiment was conducted to elucidate the effect of different dietary natural colours on the development of pigmentation in the marine ornamental clown fish, *Amphiprion ocellaris*. Five treatment groups were kept intriplicate *viz.* T1- without any pigments in diet, T2- with 2% of paprika oleoresin, T3- with 2% of curcumin, T4- with 2% of chlorophyll and T5- with a combination of all the three pigments @ 2% in feed.

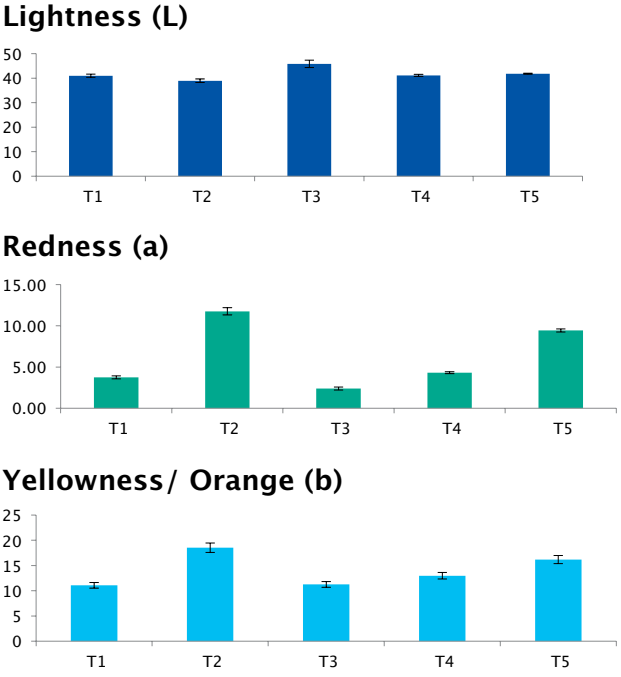
Sampling was done after completion of experimental period (60 days). Tissue samples of gill, gut, muscle and whole body were collected, processed and stored at -80°C for analysis.

Parameters such as skin colour intensity, specific growth rate %, weight gain %, feed efficiency ratio, feed conversion ratio, average daily growth, viscero-somatic index, digestive enzyme parameters- amylase, protease, lipase and whole body proximate composition were analysed.



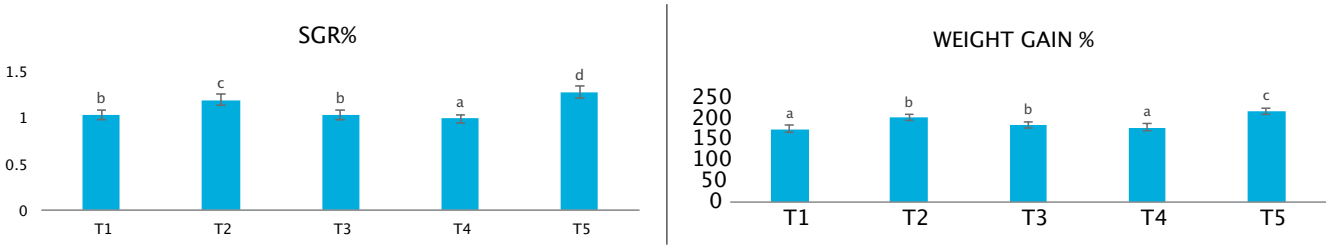
L,a,b colour-opponent space model

Skin colour intensity of fish was measured using HunterLab™colour analyser at ICAR-CIFT, Kochi. The skin colour intensity of fishes was measured in a scale of Whiteness/Lightness (L), redness (a) and yellowness/ orange hue (b). The value of 'L' ranges from 0 to 100. L value of '100' indicates absolute brightness while '0' indicates absolute darkness. A comparatively higher and positive value of 'a' and 'b' indicates an increased level of whiteness, redness and yellowness/ orange, while negative values of 'a' and 'b' indicate green and blue colours respectively.



Skin colour intensity in *A. ocellaris* with respect to different treatments

The fishes from each replicate were packed separately in polythene bags in live condition and transported to ICAR-CIFT, Kochi. Fishes were anaesthetised using clove oil (@ 50µL/L) prior to keeping them in the dish for colour intensity measurement. The fishes were reinstated after the analysis of skin colour intensity. Other parameters were analysed as per standard protocols.



SGR% and weight gain % in *A. ocellaris* with respect to different treatments
Data is expressed as Mean ± SE n=3. Mean values in the bars with different superscript differ significantly (P<0.05).

Proximate composition (% DM basis) of the carcass of experimental fish

Treatments	Crude protein (%)	Ether extract (%)	Ash (%)	AIA (%)	NFE (%)
T1 (C)	70.07	15.66	13.63	0.20	0.64
T2 (PAP2)	71.82	16.55	11.06	0.23	0.57
T3 (CUR2)	68.80	20.22	10.14	0.24	0.84
T4 (CHL2)	71.72	15.97	11.52	0.41	0.79
T5 (COM2)	73.20	15.12	11.02	0.26	0.66

Significant differences in carcass composition of fishes were not observed among the treatments.

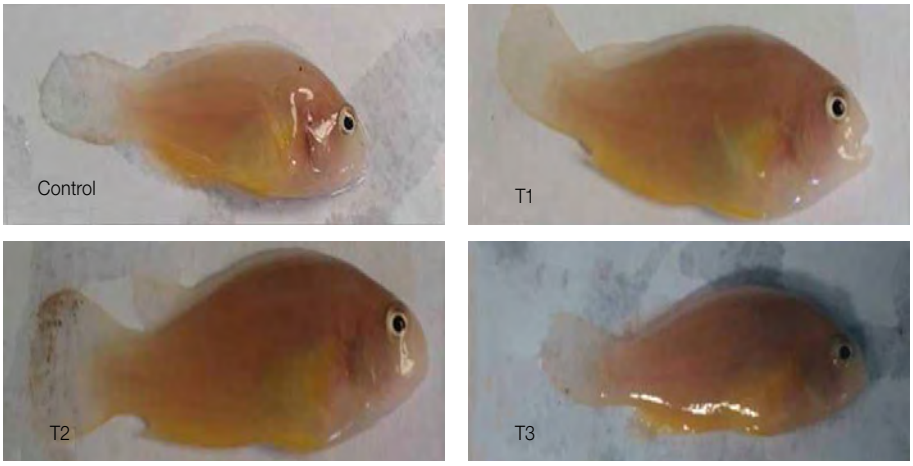
Colour intensity of skin in terms of redness and yellowness measured was significantly (P<0.05) different and highest in fishes of T2 group (i.e. fed with 2% of paprika oleoresin along with feed) with highest index of redness and yellowness as compared to all other treatments. Lightness was highest in T3 and lowest in T2.

Significant differences (P<0.05) among treatments were observed in the case of specific growth rate and weight gain %. The highest value of SGR% was observed in T5, while the lowest was in T3. WG% was highest in T5 and lowest in T1. No significant differences between treatments were observed in the case of FCR, FER and ADG.

The pigments present in the feed have a direct influence on the skin coloration in *A. ocellaris*. Colour imparted in fish due to paprika oleoresin incorporated feed was found to be superior, while the growth performance was better when a combination of pigments was used. Further optimisation of pigment levels in combination may have a positive effect on both skin colour intensity as well as growth of the fish. The linkage of pigments with metabolic pathways of growth and underlying mechanisms of skin colouration in fish has to be elucidated with biochemical as well as molecular tools in order to reveal the mode of action.

Dietary supplementation of seaweed, *Portieria hornemannii* on growth, survival and pigmentation in clown fish (skunk), *Amphiprion sanadacinos*

An experiment to evaluate the effect of dietary supplementation of seaweed, *Portieria hornemannii*, on growth, survival and pigmentation in Clown fish (Skunk), *Amphiprion sanadacinos* was carried out.



Experimental skunk fishes of different treatments

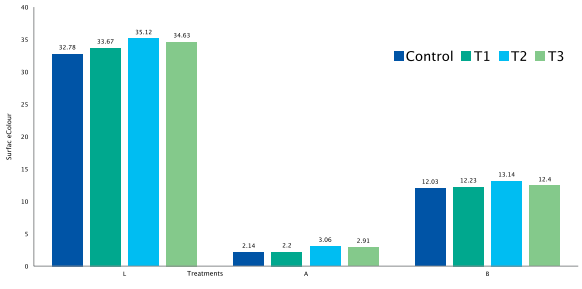
Four experimental feeds were prepared, incorporating graded levels of seaweed powder i.e 0%, 10%,15% and 20% and considered as T0, T1, T2 and T3 treatments respectively. The uniform size group of fishes (*Amphiprion sanadacinos*) with an average weight of 0.70±0.20 g were randomly distributed in four treatments with triplicate. The fish were fed to apparent satiation twice daily (10:00 and 16:00 hrs) and experiment was conducted for 30 days. The growth parameters (Weight gain%, Specific Growth Rate %), Survival and pigmentation (skin colouration and tissue carotenoid) were studied.

Colour analysis (L-Brightness, a^+Red, a^-Green, b^+ yellow, b^-Blue)

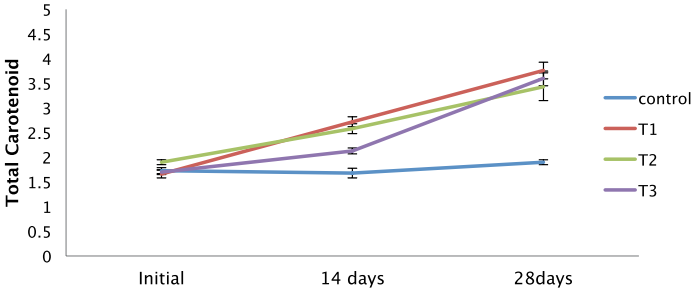
Colour measurements were carried out using the Hunter Lab™ colour analyser at ICAR- CIFT and the measurements were expressed in L,a,b scales. The result showed that values of brightness and redness were significantly higher in treatment T2 but value for yellowness is not significantly different within treatments. The dietary inclusion of seaweed powder has a significant effect in enhancing the brightness and redness of the fishes.

Total carotenoid concentrations of the fishes fed three experimental diets with different levels of seaweed and a control diet were shown in the Figure. The fishes fed with seaweed incorporated diets were having highest total carotenoid concentration than the control fishes at the end of the experiment but among the treatments fed with seaweeds, no significant difference was found. Fortnightly variation in the total body carotenoid deposition were represented in graph. But the fishes showed faded colouration when fed with diets having higher inclusion levels of seaweed. The survival of the fishes was lowest in T3. These adverse effects may be due to high fiber and ash content in feed.

The weight gain percentage (WG %) and Specific Growth Rate percentage (SGR; % day -1) were not significantly different among different treatments. However, higher growth was



Surface colour analysis (L, a, b) by colour analyser of skunk clowns



Carotenoid increment throughout the experimental period

observed in T1(10%) and T2 (15%) groups. Poor survival was observed in T3 group (60±5%) fed with higher level inclusion (20%) of the seaweed, *P. hornemannii* in feed.

Total muscle carotenoid deposition and body surface colour were significantly higher in fish fed with 10% and 15 % dietary inclusion level of *P. hornemannii*. Dietary supplementation of seaweed, *P. hornemannii* at the rate of 10 to 15% has the potential to enhance skin colouration in clown fish.

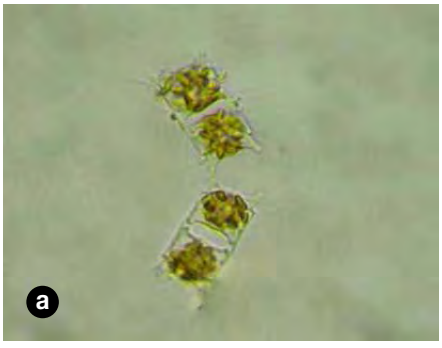
New microalgae from Gulf of Mannar

Five new algae have been isolated and purified from Gulf of Mannar region. Two algae have been identified up to genus level as *Biddulphia (Odontella)* sp. and *Coelastrella* sp. Molecular identification has been done in one species and deposited in GenBank.

Microalgal powder from microalgae

Five microalgae namely, *Nannochloropsis* sp., *Isochrysis galbana*, *Pavlova lutheri*, *Chromulina freiburgensis* and *Chaetoceros calcitrans* were taken for microalgal powder harvesting study.

Harvesting of algae can be done by filtration, centrifugation, and flocculation. In this study, centrifugation was used to harvest the biomass. When the cultures reached stationary phase, cell counts were taken by a haemocytometer and biomass estimations were made (Table). The biomass was then harvested from one litre of each algae by centrifugation at 10000 rpm for 20 min. The supernatant was removed and pellets were collected. The wet weight for the five algal species was noted and the samples were kept for freeze drying in a lyophilizer at -55^{0}C for 3 hours. The yield in terms of wet weight and dry weight is given in the Tables below.



a. *Biddulphia* (*Odontella*) sp.
b. *Coelastrella* sp.

Average cell count of marine microalgae

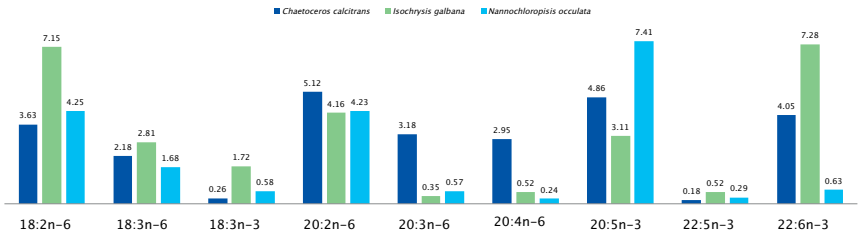
Microalgae	Average cell count (Mean ± S.D) x10^6
Nannochloropsis sp.	2.10 ± 0.05
I. galbana	5.13 ± 0.16
P. lutheri	6.69 ± 0.14
C. freiburgensis	7.48 ± 0.04
C. calcitrans	2.41 ± 0.06

Biomass of collected marine microalgal powder

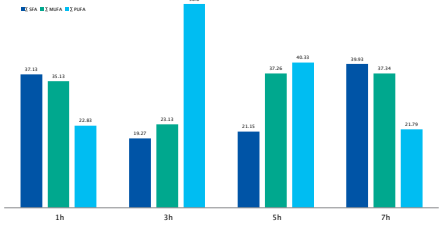
Microalgae	Wet weight (g/L)	Dry weight (g/L)
Nannochloropsis sp.	0.11	0.010
I. galbana	0.415	0.100
P. lutheri	1.019	0.100
C. freiburgensis	0.55	0.088
C. calcitrans	1.698	0.220

Fatty acid composition of important microalgae for mariculture

Three different marine microalgae strains, which have potential importance in mariculture were screened and identified as *N. occulata*, *I. galbana* and *C. calcitrans*. Among the different experimental microalgae, *I. galbana* was found to contain greater content of aggregate PUFA (> 26%), followed by *C. calcitrans* (26.41% TFA), and *N. occulata* (19.88% TFA). The aggregate n-3 LC-PUFAs was predominant with *I. galbana* (12.63% TFA), followed by *C. calcitrans* (9.35% TFA), and *N. occulata* (8.91% TFA). Among different n-3 LC-PUFAs, the fatty acid DHA was found to be present in higher amount (7.28% TFA) in *I. galbana*, followed by *C. calcitrans* (4.05% TFA), and *N. occulata* (0.63% TFA). The fatty acid EPA was present in higher amount (7.41% TFA) in *N. occulata*, followed by *C. calcitrans* and *I. galbana*. Importantly, the proportion of n-3/n-6 fatty acid content was found to be higher in *I. galbana* (0.84) followed by *N. occulata* (0.81) and *C. calcitrans* (0.55).



Production, purification and biochemical characterisation of an extracellular alkalophilic lipase from marine Gammaproteobacterium KX 272637



Comparative fatty acid composition of oil hydrolysed with purified lipase

An extra-cellular lipase was produced from Gammaproteobacterium KX 272637 and purified by sequential purification process. The crude lipase extract had an activity of 0.63 (µ/mg) of culture medium when the bacterium was cultured for 48 h at 37 °C and pH 8.0. The enzyme was purified 60-fold with a specific activity of 36.33 (µ/mg) after gel elution. The lipase had a V_{max} and Km of 625 mM/mg/min and 98 mM, respectively, with 4-nitro phenylpalmitate, as calculated from the Line weaver-Burk plot. The lipase exhibited optimum activity at temperature 55 °C and pH 10.0.

The catalytic activity was enhanced by K^{+}, Fe^{3+}, Ca^{2+}, Na^{+} and Mg^{2+} ions. The lipase activity was inhibited by Cu^{+} and Mn^{2+} even at low concentration. The purified lipase was found to hydrolyze refined liver oil of leafscale gulper shark yielding a maximum total PUFA concentration of 56% after 3 h of enzymatic hydrolysis.

Nutritional qualities of common edible cephalopods

Nutritional composition of the edible portions of five commercially important species of cephalopods from Arabian Sea was evaluated. The selected species included *Amphioctopus neglectus*, *Cistopus indicus*, *Uroteuthis duvauceli, Sepia pharaonis* and *Sepiella inermis*. The cephalopods contain proteins with balanced proportions of essential to non-essential amino acids (~ 1.2). The n-3/n-6 polyunsaturated fatty acid ratio of *U. duvauceli* was significantly greater (~10, $P < 0.05$) than other cephalopods, and may consequently serve as a substitute to balance the greater admission of n-6 fatty acids in our standard utilisation of vegetable oil.

Lobster nutrition

A 120-day experimental trial was completed to compare the effects of two formulated pellet diets, a tilapia meal based moist pellet diet with a protein content of 60% and a sardine meal based extruded pellet diet with a protein content of 40%, on the growth and survival of juvenile spiny lobsters (*Panulirus homarus*) having an initial body weight of 75-90 g and carapace length (CL) of 40-45 mm.

Moist feed formulation gave good acceptance, and survival rate was comparable to that of the control. Moist diet fed lobsters showed a survival rate of 82% and FCR of 8, while clam-fed control animals gave a survival rate of 85% with FCR of 5. Extruded pellet diets were not readily accepted by the juveniles and had to be dipped in clam extract and air-dried before feeding. Survival was poor and growth was insignificant.

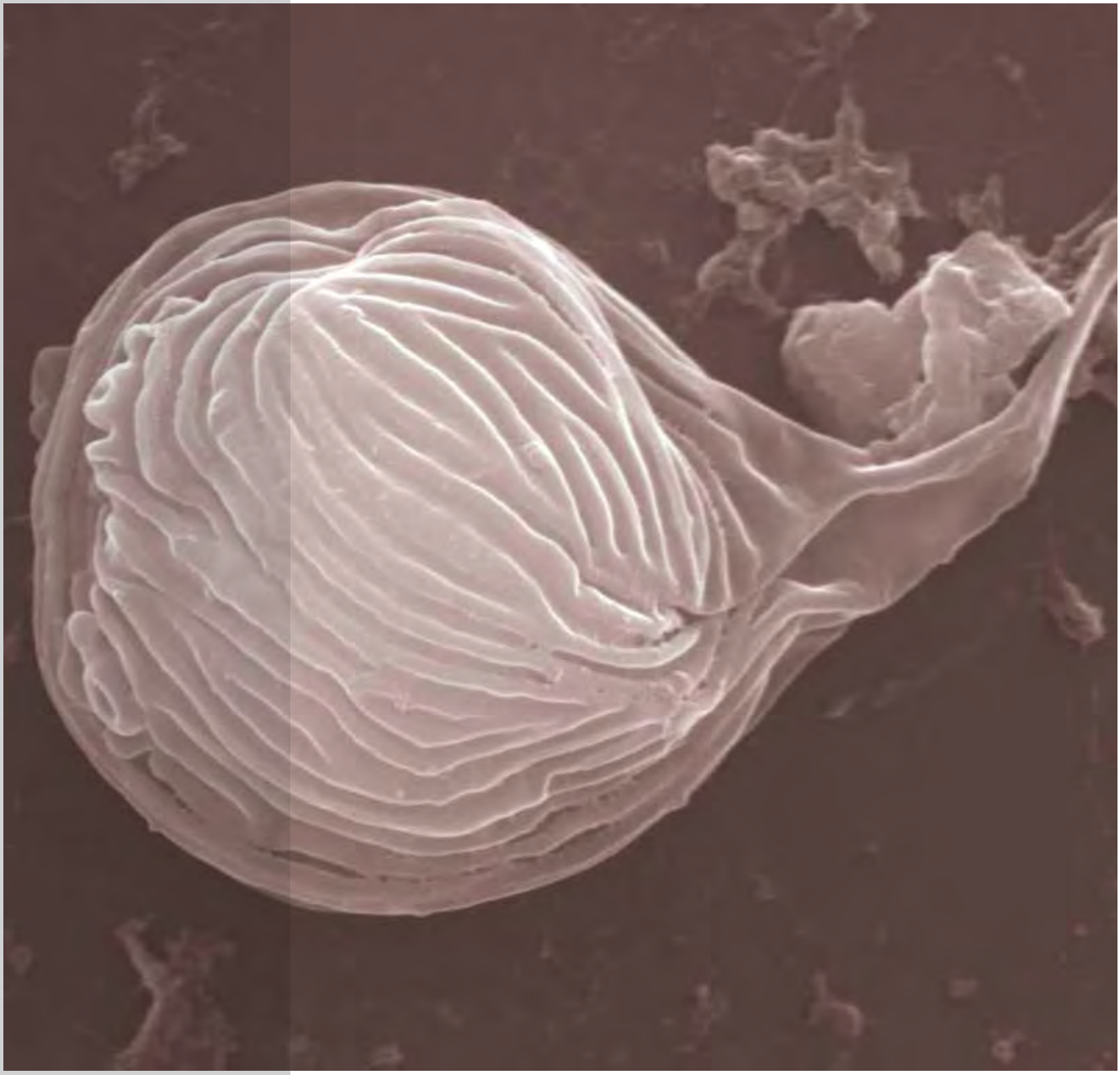
Hepatopancreas and muscle tissues from all three treatment groups were analysed for proximate composition. Protein in muscle tissue were higher in animals fed on experimental diets when compared to the control animals and lipid content was not significantly different between control and formulated diet fed animals. Carbohydrate levels were however, much lower in formulated diet-fed animals, indicating that glycogen and carbohydrate levels were very low, and needs to be improved for better meat conversion.

Development of micro-bound diets for sand lobster larvae

Micro-bound feeds are being formulated for sand lobster, *Thenus orientalis* / *unimaculatus* phyllosoma larvae, using binders such as egg albumin and different diet ingredients including krill paste, artemia paste and clam meat.

Diet ingredients were homogenised individually and filtered through a 10 µm mesh to get a smooth extract. The extracts and binder solution were blended together in different proportions and expelled through a syringe into a bath of hot water to form spherical/elongated microdiets. Preliminary tests with stage I phyllosoma larvae of sand lobster showed good acceptance by larvae.

Lobster phyllosoma feeding on microdiet



Fish health and marine bioprospecting

Research project: FISHCMFRISIL201202600026

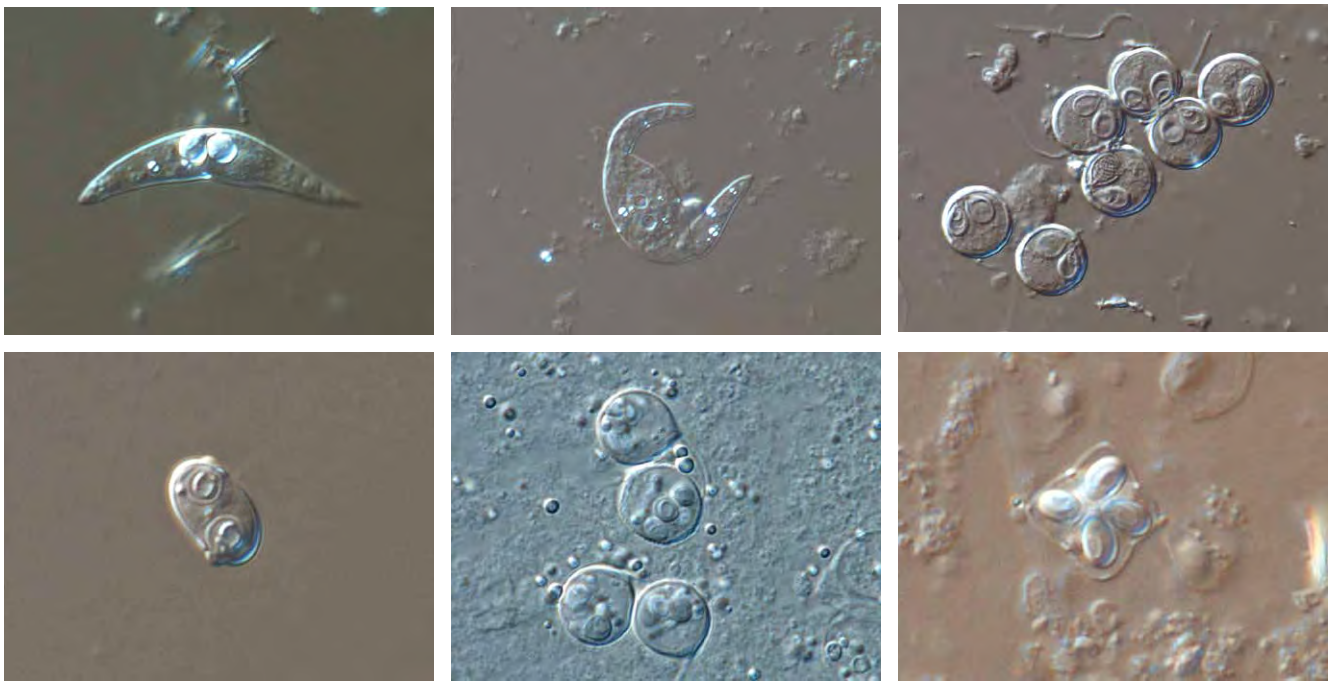
Disease investigations in finfishes

Parasitic infections:

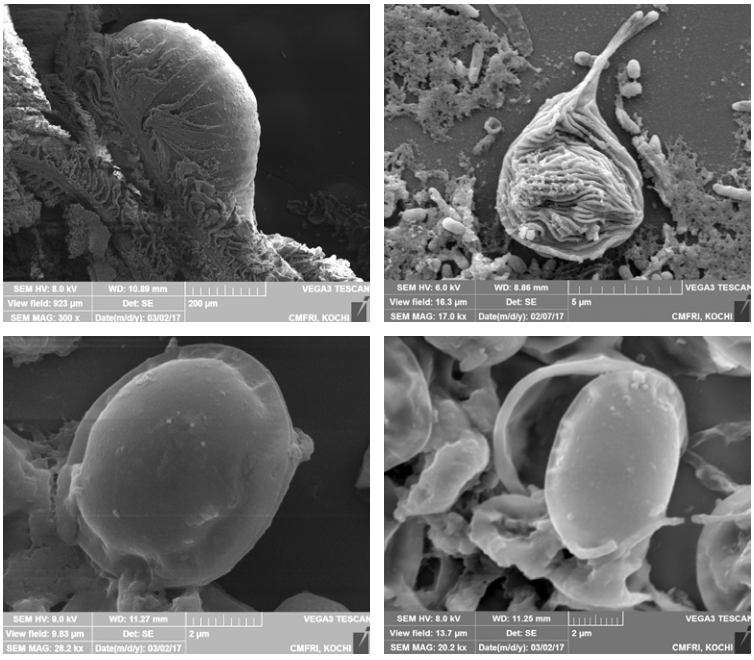
Protozoan infections were reported from various finfishes. Among the 14 different fish species screened for the presence of parasites, myxosporeans belonging to 8 different genera namely,

Ceratomyxa, Ellipsomyxa, Zschokkella, Chloromyxum, Myxobolus, Auerbachia, Ortholinea, and *Kudoa* were recovered. Prevalence of infection ranged from 7.14% to 100% while the overall prevalence stood at 58.36%.

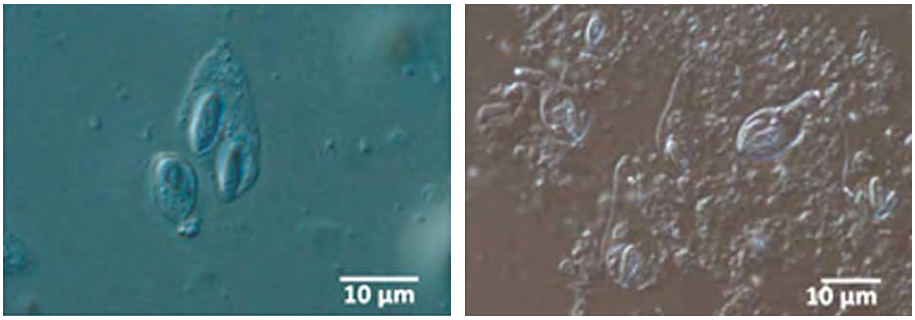
Development of *Auerbachia ignobili* in *Caranx ignobilis* was studied in detail. *A. ignobili* develops in hepatic tissues and mature spores and developmental stages are passed out along with bile into gall bladder.



Myxosporean parasites reported from food fishes



SEM images of myxosporeans



Developmental stages of *A. ignobili*

Screening of marine ornamentals also revealed the presence of the myxosporeans, *Ceratomyxa* and *Zschokkella*. The prevalence of infection ranged from 1.25% to 100%, while the overall prevalence stood at 86.04%.

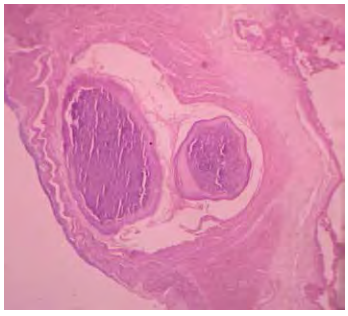
Infections with *Amyloodinium ocellatum* was reported from cobia and pompano, treatment with *Chloroquinine phosphate* for a week without water exchange could eliminate the parasite.

Infection with the microsporean parasite, *Glugea* sp. was reported from *Uranoscopus marmoratus* at Mandapam. Whitish-yellow xenomas up to 4mm in diameter were attached to viscera, were enclosed in a thick fibrous capsules and harboured numerous spores.

Infestation with sea lice (*Lepeoptherius* sp.) was reported from *Epinephelus malabaricus* at Mandapam. The parasites infested the skin and gills, leading to mortalities in grouper broodstock.

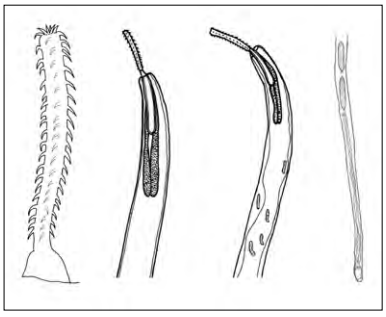
A new species of acanthocephalan parasite, *Filisoma keralensis* n. sp. infecting the intestine of *Scatophagus argus* was reported. Scanning Electron Microscopy of the acanthocephalan parasite, *Tenuiproboscis keralensis* revealed the morphology of the parasite and extensive damage at the site of infection.

Xenoma attached to viscera

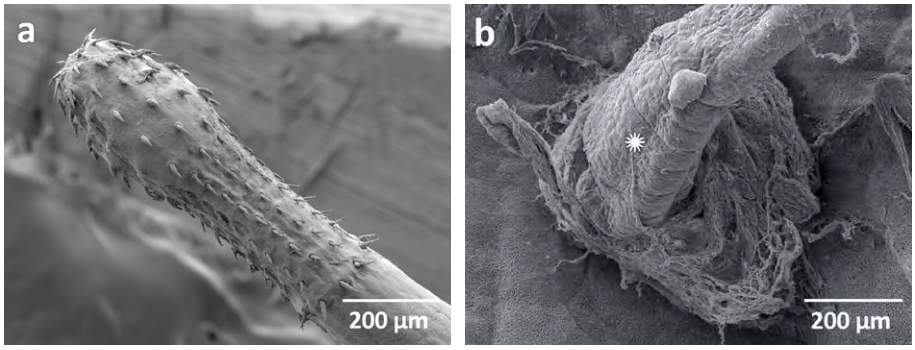


Cross section of xenoma

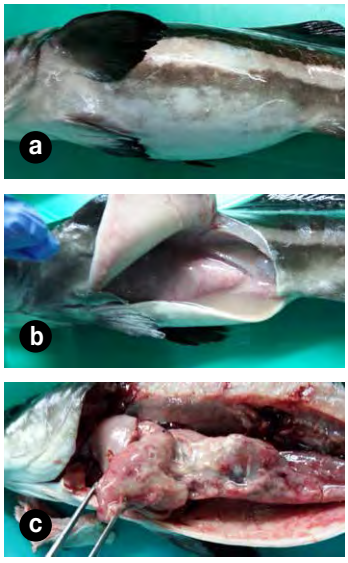
Lepeoptherius sp. infesting *E. malabaricus*



Filisoma keralensis n. sp.



Tenuiproboscis keralensis a) proboscis. b) damaged intestinal epithelium

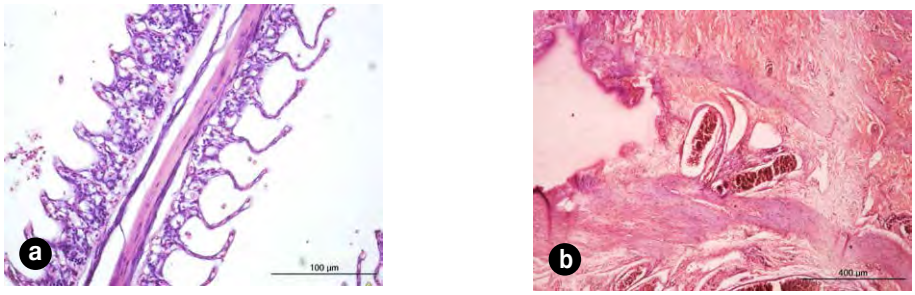


Gross lesion in cobia infected with *P. damselae* ssp. *damselae*.

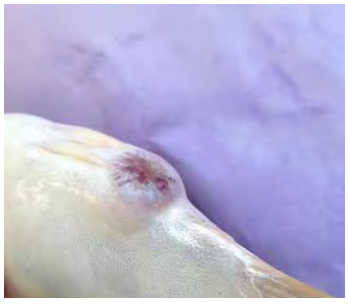
a. swollen abdomen.
b. abdominal cavity filled with fibrinous exudates.
c. fibrinous pericarditis and peritonitis

Bacterial infections:

Dual infection with *Vibrio harveyi* and two strains of *Photobacterium damselae* ssp. *damselae* was reported from cage farmed cobia (*Rachycentron canadum*) at Karwar. Histopathologically, changes like necrosis, inflammation and congestion were noticed in liver, kidney and spleen. Pathogens were confirmed by rDNA amplification and sequencing, multiplex PCR, species specific PCR and biochemical characterisation. Enzymatic and antibiogram profiling of the pathogens were also carried out.



Histopathology of cobia infected with *P. damselae* ssp. *damselae*: a. hyperplasia of the gill. b. increased expression of melanomacrophage centres in the kidney



Vibrio infection in pompano

Molecular cloning and recombinant expression of outer membrane protein K (ompK) from *Photobacterium damselae* using pET 22 expression vector and BL 21 cells were carried out.

Disease outbreaks caused by *V. parahaemolyticus* and *V. alginolyticus* in cobia and by *Streptococci* spp-2 and *Bacillus* spp. in pompano were diagnosed at Mandapam. *P. aeruginosa* was also found associated with mortalities.

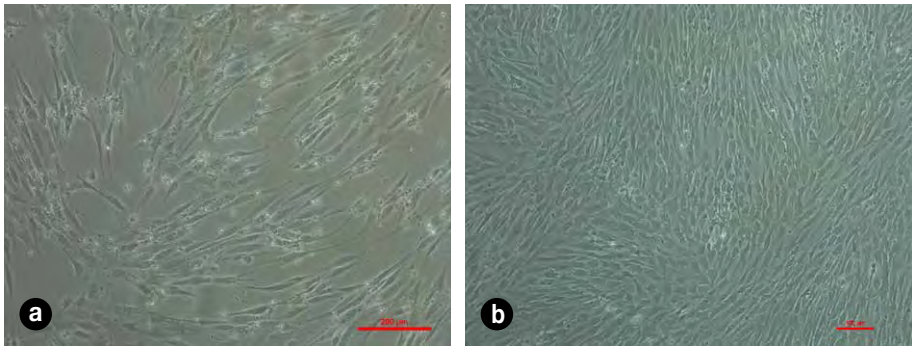
Disease outbreaks involving mixed infection with *Aeromonas hydrohila*, *Acinetobacter* sp. and *Enterobacter cloacae* was reported in Silver pompano in Kochi. *Vibrio* infections were reported from the nursery phase and broodstock of *Trachinotus mookalee* at Visakhapatnam. The clinical symptoms included haemorrhages on body, blackened gills and exophthalmia. Infection with *Vibrio* sp. was also observed in *T. mookalee* at Kochi.

Viral infections

Nervous Necrosis Virus (NNV) infection in cage cultured sea bass at Karwar was diagnosed using "β-Nodadetect" a RT- LAMP based diagnostic kit developed by CMFRI. RNA2 coat protein gene of NNV was cloned and sequenced and the sequence showed maximum similarity to red spotted grouper nervous necrosis virus genotype. Viral nervous necrosis was also reported from orange spotted grouper at Visakhapatnam. VNN was diagnosed using Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) with OIE listed primers.

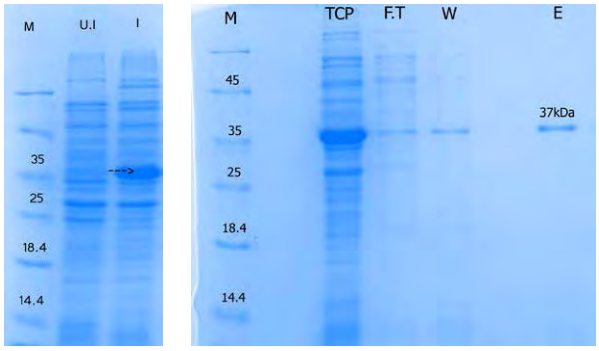
Culture of Betanodavirus in SISS cell line (Seabass Spleen cell line) was attempted. Clear cytopathic effects on SISS cells were first observed at 2 days post-inoculation (dpi). Cell elongation started at 2 dpi, followed by rounding and clumping of cells at 3 dpi and 90% cell death was observed at 5 dpi. Once CPE was observed, RNA was isolated from supernatant as well as cells and checked for virus specific sequences using "β-Nodadetect" and also through RT- PCR and sequencing for confirmation.

RNA2 coat protein of betanodavirus is an ideal candidate for vaccine development. RNA2 coat protein gene was isolated and used for producing recombinant RNA2 protein in a prokaryotic expression system. The expression conditions were optimised using an autoinduction system to obtain high level expression (400mg/l of culture) of rRNA2. The purified protein will be



SISS cell line showing CPE on infection with betanodavirus. a. control. b. 4dpi

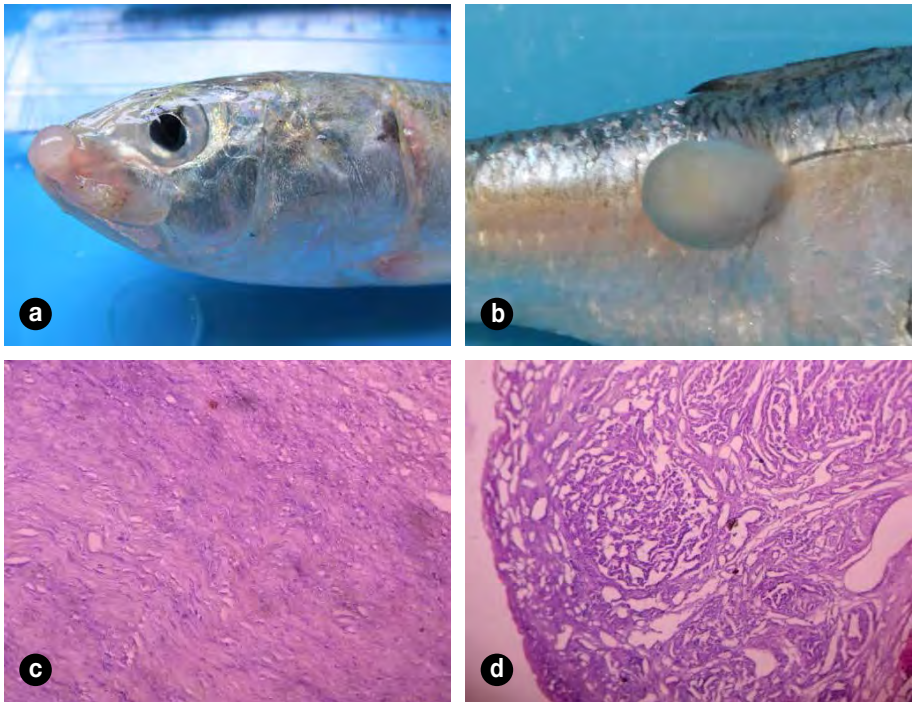
useful in developing Recombinant Vaccine against betanodavirus and immune assays for detecting betanodavirus.



SDS PAGE of rRNA2 coat protein gene expression; M-Marker, U.I-uninduced, I – Induced

Neoplasia in sardine

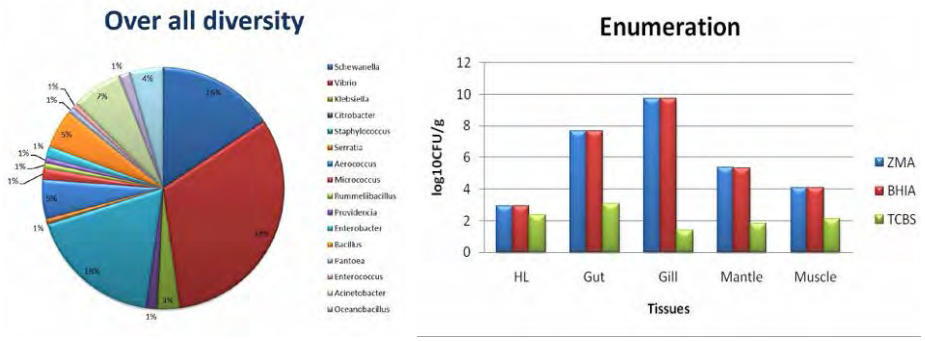
Incidence of tumours was reported in *Sardinella longiceps* from Mandapam. Tumour masses observed on the upper maxillary region and skin were identified as fibrosarcoma and adenocarcinoma respectively, based on histology.



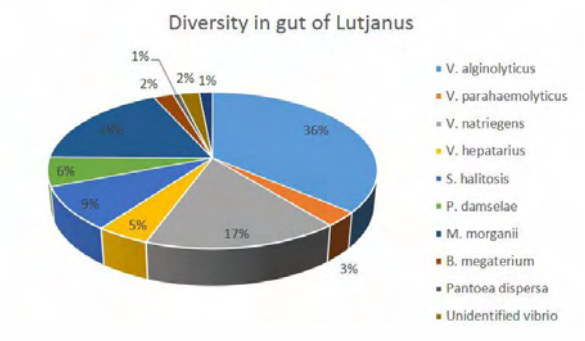
Neoplasia in sardine; a. on upper maxilla b. on skin histology of tumours in sardine c. fibroma d. adenocarcinoma

Health management

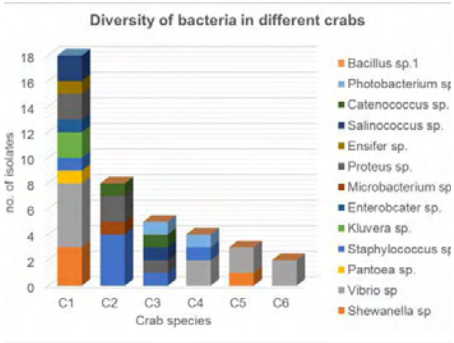
Density and diversity of cultivable bacterial assemblages associated with haemolymph and tissues (gut, gill, mantle and muscle) of apparently healthy green mussel, (*Perna viridis*) were studied. Density and diversity of cultivable heterotrophs from the hemolymph of six different crab species was carried out. Density and diversity of cultivable heterotrophs present in the gut of apparently healthy Mangrove red snapper, (*Lutjanus argentimaculatus*) was evaluated. The isolates were studied for their contribution towards digestive enzymes and disease resistance of host. Antagonistic potential of different isolates was also studied.



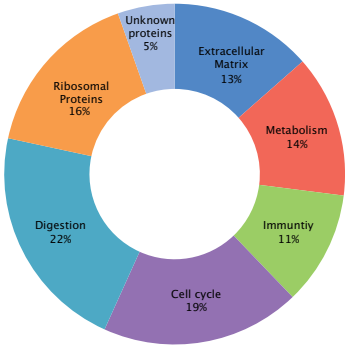
Perna viridis – a) bacterial diversity; b) bacterial density



Bacterial diversity in the gut of *L. argentimaculatus*



Bacterial diversity in crab haemolymph



Functional classification of genes in *C. madrasensis*

Suppressive Subtractive Hybridisation (SSH) technique was used to obtain differentially expressed genes in wild and laboratory maintained *Crassostrea madrasensis*. Vectorette PCR was performed to obtain full length sequences of genes identified using SSH. Amplification was obtained for genes of Rhamnose binding lectin, mitochondrial like ATP synthase, lipid binding protein, calreticulin and collagenase. The products were cloned and vectorette clone library constructed. Positive clones were then sequenced. Rapid amplification of complementary ends (RACE) technique was used to get the complete length of calreticulin gene.

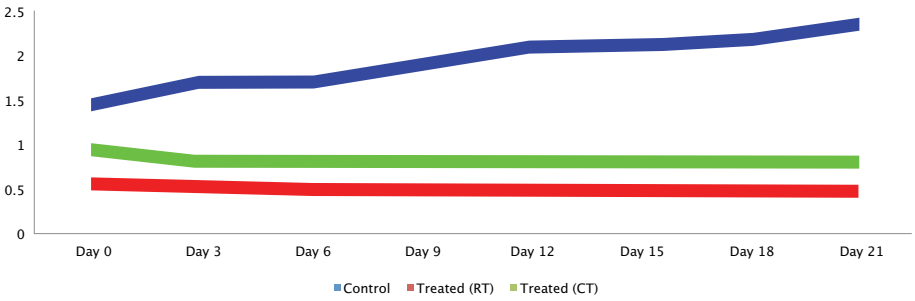
Suppression Subtractive Hybridisation of *Etroplus suratensis* maintained in zero and 36 ppt was carried out to identify differentially expressed genes capable of salinity tolerance.

Health monitoring of brood stock and larvae of lobsters and Indian halibut was continued, infestation with carcinonemertan worms were frequently observed in berried female lobsters at Chennai.

Developed quarantine measures for sand lobster berry screening and handling. Larval rearing tank (LRT) system was modified to avoid handling of phyllosomal stages after introduction to the LRTs. LRTs with first phase recirculation, followed by static water, performed better in stabilizing the larval culture media and microbial status than a complete static water or recirculatory system for the entire duration of larval cycle.

Regular monitoring of water quality in live feed culture tanks was carried out at weekly intervals. Total bacterial loads of water were high in *Chaetoceros* culture tanks and significant variations in *Vibrio* loads were observed in microalgae and rotifer culture tanks.

A one-month experimental study on the elimination of Vibrios in water with the application of probiotic was carried out. The study revealed that the probiotic can effectively reduce and eliminate Vibrios in culture tanks with a dosage of $1x10^4$ cfu/ml when applied for every 10 days.



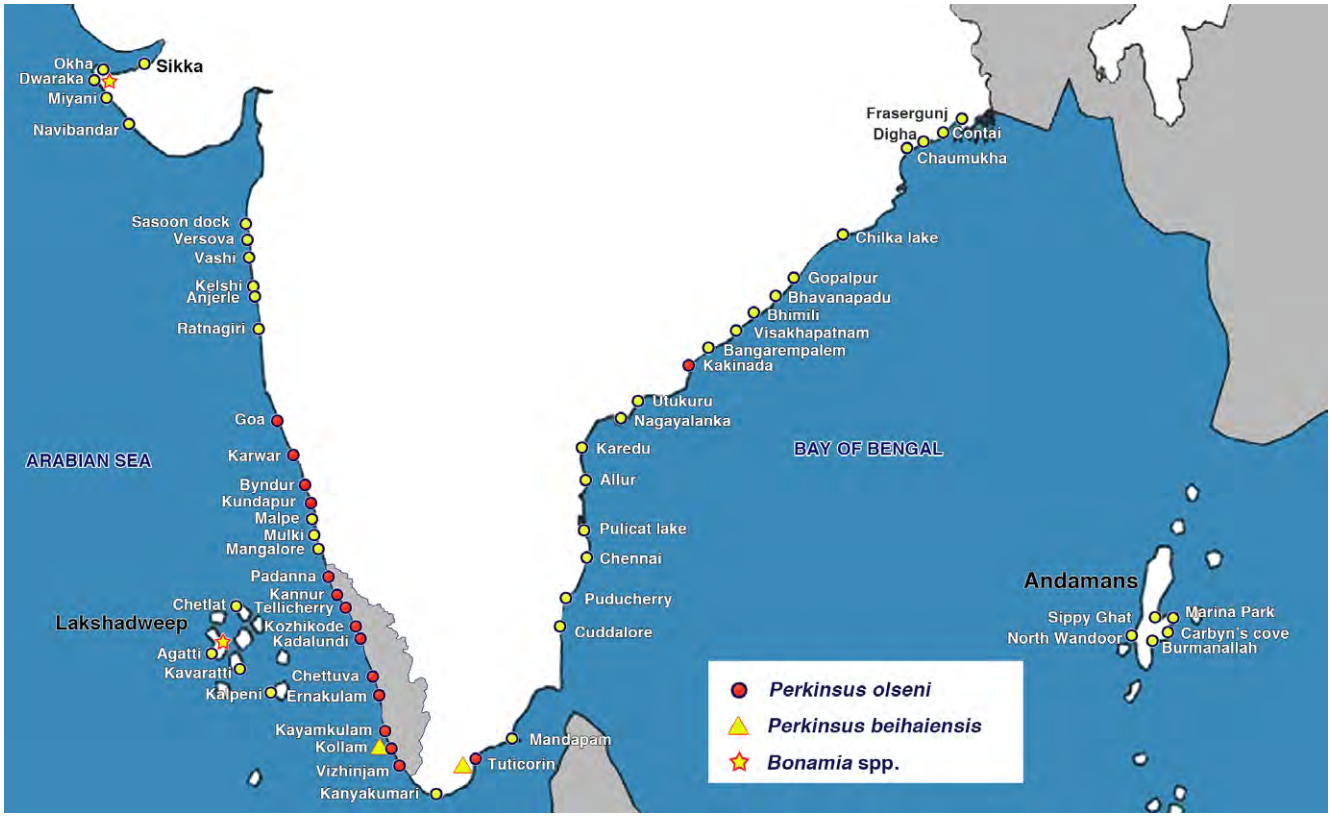
Graph showing *Vibrio* loads of water in probiotic treated and untreated culture tanks

Aquatic animal disease surveillance:

Research project: EFP-13

Under the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD), regular screening of wild and farmed bivalves for OIE listed pathogens were carried out along the east and west coasts of India including Lakshadweep and Andamans. A total of 1703 bivalve samples belonging to 16 species were collected and screened. Base line data/information

Geographical distribution of *Perkinsus* spp.



along with the GPS locations of farms were also collected. A total of 863 samples of farmed *P. viridis* and *C. madrasensis* were screened. Infections with Perkinsus beihaiensis and *P. olseni* were observed. Investigation on the mortality of farmed green mussels in Kerala revealed that, infections with *P. olseni* along with drastic variations in climate caused the mortalities. *Paphia malabarica* was found infected with two species of *Perkinsus* – *P. olseni* & *P. beihaiensis*.

All India Network Project on Fish Health

Research project: EFP-36

Information regarding products/chemicals used in aquaculture were collected through a questionnaire based survey. More than twenty commercial products were identified and categorised under drugs, food and feed supplements and probiotics.

Estimation of dose and drug withdrawal period for OTC in cobia is being carried out. Safety study for Emamectin benzoate has been initiated. Screening of imported marine ornamental fish for OIE listed pathogens in quarantine/hatchery facilities is being carried out.

Economic loss assessment based on loss/mortalities in mussel farming in Kasaragode carried out. The farming season experienced 70% mortality and the losses were estimated to be around 8–8.5 crores.

ICAR-Consortia Research Platform on Vaccines & Diagnostics

Research project: EFP-35

A LAMP based diagnostic for detecting *Perkinsus* sp. infections in bivalves was developed. The LAMP reaction is capable of detecting up to 100 copies of the template. Validation of the LAMP using field collected samples of infected mussels is progressing.

a. *Perkinsus* cells developing in culture media
b. LAMP based diagnostic for detecting *Perkinsus* infections.

In-vitro cultures of *Perkinsus* sp. using gills and/or mantle of infected mussels were carried out. Hypnospores obtained from RFTM culture were allowed to develop in sterile seawater and the released dinospores were transferred to Dulbecco's minimal essential media (DMEM, Himedia) containing 10% FBS and antibiotics–pencillin (50 units/ml) and streptomycin (500µg/ml). Cell proliferation was prominent in media adjusted to 35ppt salinity. Identity of the cultured pathogen was confirmed using PCR. Pure culture of the parasites can be used as antigens for the development of immunodiagnostics.

Gene coding 37 kDa *V. anguillarum* GAPDH was cloned and sequenced from a pathogenic strain of *V. anguillarum* isolated from infected Asian seabas (*Lates calcarifer*). The *V. anguillarum* GAPDH gene was recombinantly expressed in fusion with a 6x histidine tag in *Escherichia coli* using pET28b expression vector. The recombinant expression conditions were optimised for overexpression of the recombinant protein. The recombinant GAPDH

protein was purified using immobilised metal ion affinity chromatography (IMAC) followed by final polishing purification using gel filtration chromatography to obtain a homogenous pure preparation of recombinant Glyceraldehyde-3-phosphate dehydrogenase (rGAPDH). A scalable methodology for over-expression of rGAPDH in *E. coli* expression system and purification of rGAPDH using chromatographic methods was established. The purified rGAPDH will be used for studying the immune protection imparted in Asian seabass for production of vaccine against *V. anguillarum*.

Bioprospecting

Research project: FISHCMFRISIL201202600026

Cadalmin™ Antihypercholesterolemic extract (Cadalmin™ ACe), a nutraceutical to combat dyslipidemia and obesity: Cadalmin™ ACe is a nutraceutical product developed from seaweeds. Bioactive pharmacophore leads from the product inhibit hydroxymethyl glutaryl coenzyme A reductase, various target receptors and other rate limiting enzymes, which are responsible to cause obesity and dyslipidemia. Preclinical trials showed no toxicity related significant changes in renal or hepatic function, hematological indices and serum biochemical parameters in the experimental subjects. The LD_{50} value of the nutraceutical recorded greater than 5000 mg/kg body weight, and therefore, do not have any side effects. Shri Justice P. Sathasivam, Hon'ble Governor of Kerala, released the product at ICAR-Central Marine Fisheries Research Institute in Kochi on 18th February 2017.

Cadalmin™ ACe from seaweeds

Antimicrobial therapeutic product from seaweed-associated bacterium: Antibacterial polyketide compounds isolated from sea weed associated heterotrophic bacterium showed activity against pathogenic bacteria. An antimicrobial therapeutic product was developed from the seaweed-associated bacterium. This finding will provide promising therapeutic agents against infections with multi-resistant Gram-negative pathogenic bacteria and methycillin resistant Staphylococcus aureus (MRSA).

Green drug delivery system, and antibacterial ointment from seaweeds: Anti-inflammatory pharmacophore-encapsulated, seaweed-derived hybrid drug delivery system was assessed for oral drug delivery and topical application. The product exhibited sustained release of the encapsulated drug in the gastric fluid which makes it a biocompatible carrier for controlled oral drug delivery. An anti-microbial ointment for topical application was prepared based on seaweed-based active ingredient. The product did not induce any adverse toxicity on different clinical parameters.

Antibacterial potential of seaweed associated Gamma proteobacterium: Seaweed associated bacteria belonging to Gamma proteobacterium were screened for their bioactivity against pathogenic bacteria. The polyketide compounds displayed significant antibacterial activities against clinically important pathogens. These could be used as promising therapeutic leads to control the bacterial pathogens including the antibiotic resistant microbes of clinical significance.

Fucoidan possessing antibacterial and immunostimulant properties was extracted from brown seaweeds. Immune response of cobia fingerlings could be improved when fed with this extract.

Bio-prospecting of bacterial isolates from different marine sources for the presence of commercially significant enzymes by bacteria were carried out. Seven potential phosphate solubilizing bacterial isolates (PSI above 3), six nitrite oxidizing bacteria and thirty eight isolates with potential for biosurfactant production were identified.

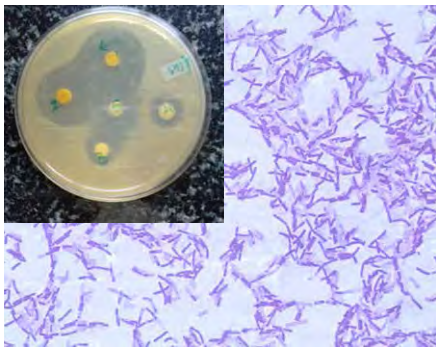
Microbiological profiling of a commercial fish waste degrading bacterial consortia namely, FISH LYSER was carried out. Isolates were screened for their waste degrading/biofertilizing/ enzymatic properties.

High value compounds/Phytochemicals

Research project: EFP-20

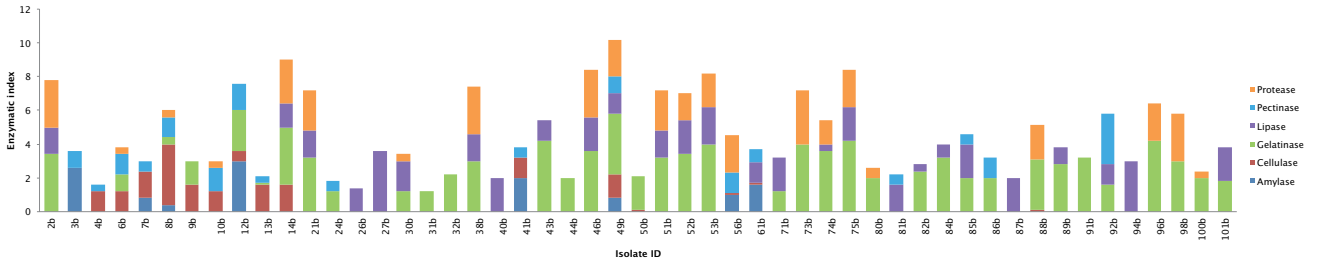
Antibacterial pharmacophores from marine bacterium *Bacillus subtilis* associated with seaweed Sargassum myriocystum

Bacillus subtilis MTCC 10407 (JF834075) associated with the brown seaweed, *Sargassum myriocystum* exhibited broad-spectra of potent antibacterial activities against pathogenic

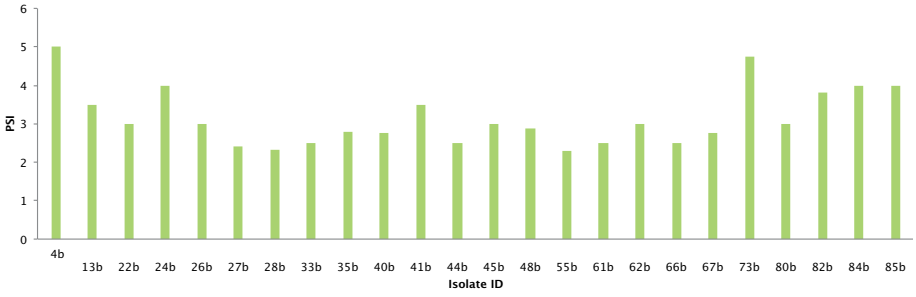


Antimicrobial therapeutic product from seaweed-associated

Green drug delivery system, and antibacterial ointment from seaweeds



Screening for commercial enzymes



Phosphate solublising activity

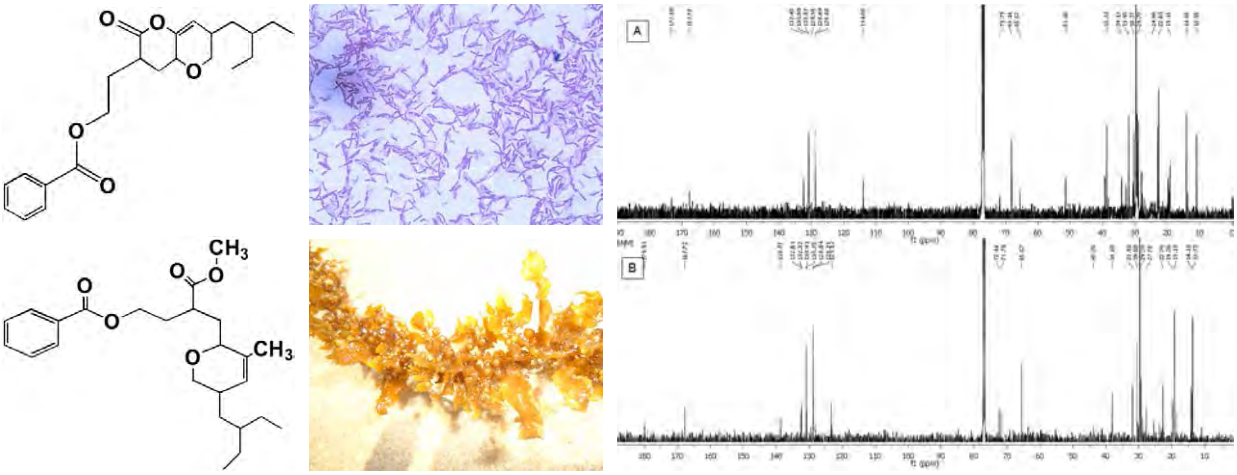
S No.	I	Strain	Genus	P	L	C	Ch	oPS	iPS	SO	AO	NO
1		F9	*Lysinibacillus xylanilyticus*	★	-	-	-	★	★	★	★	-
2		F28	*Halotalea* sp.	-	-	-	-	★	★	★	-	-
3		F45	*Bacillus oryzaecorticis*	★	-	-	-	-	-	-	-	-
4		F50	*Cronobacter condimenti*	-	-	-	-	-	★	★	-	-
5		F54	*Bacillus megaterium*	-	-	-	★	★	★	-	★	★
6		F5	*Vibrio mytili*	-	-	★	-	-	-	-	-	-

Microbiological profiling of FISH LYSER

bacteria including Aeromonas hydrophila, V. *vulnificus*, and *V. parahaemolyticus*. Two new antibacterial O-heterocyclic compounds belonging to pyranyl benzoate analogs of polyketide origin, with activity against pathogenic bacteria, have been isolated from *B. subtilis* MTCC 10407. Two homologous compounds isolated from *S. myriocystum* with lesser antibacterial properties shared similar structures with the compounds purified from *B. subtilis* and suggest ecological and metabolic relationships between these compounds.

Two rare antioxidant and anti-inflammatory oleanenes from loop root Asiatic mangrove *Rhizophora mucronata*

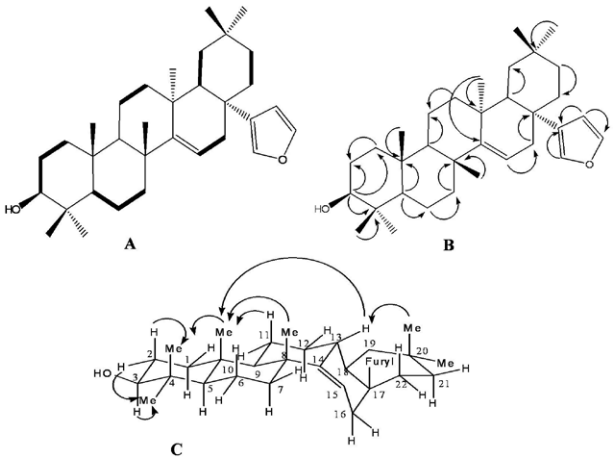
Two oleanenes, olean-18(19)-en-3b-yl-(3,6-dimethyl-3E,6Z-dienoate) and (13a)-27-frido-olean-14(15)- en-(17a)-furanyl-3b-ol representing a class of rare natural pentacyclic triterpenoids were isolated from the Asiatic mangrove, *Rhizophora mucronata*. The furanyl oleanene exhibited significantly greater antioxidative activities (IC_{50} 0.73-0.76 mg/mL), than prenylated oleanene (IC_{50} 0.84-0.96 mg/mL) ($P < 0.05$). No significant differences in anti-5-lipoxygenase activities of these compounds with the synthetic drug ibuprofen was discernible (IC_{50} 0.8-0.9 mg/mL), whilst furanyl oleanene demonstrated significantly greater anti-cyclooxygenase-2 (IC_{50} 0.84 mg/mL) and anti-5-lipoxygenase activities (IC_{50} 0.78 mg/mL) over prenylated oleanene (IC_{50} > 0.90 mg/mL). The lipophilic and steric molecular descriptors were found to occupy a prominent role in determining the bioactivities of the compounds.



Comparison of 13_C NMR between the compounds a. 1 isolated from *B. subtilis* MTCC 10407 and b. 3 from seaweed *S. myriocystum*

Biogenic guaianolide-type sesquiterpene lactones with antioxidative and anti-inflammatory properties from natural mangrove hybrid Rhizophora annamalayana

Previously undescribed guaianolide-type sesquiterpene lactones isolated from Rhizophora annamalayana were characterised as (Z)-3α,4,5,6-tetrahydro-5α-isobutyl-2β-(methoxymethyl)-7-methyl-3H-cyclohepta[b]carbo lactone (1) and (7Z)-isopentyl 3α,4,5,6,7,8-hexahydro-2β-



2D NMR correlations in oleanane triterpenoid 2. (A) 1H-1H COSY couplings (bold face bonds); (B) Key NOESY couplings are indicated as double-barbed arrows

((E)-11-methylbut-10-enyl)-1-oxo-2H-cyclohepta[b] furan-6-carboxylate (2). Compound 2 displayed greater antioxidative activities {1, 1-diphenyl-2-picrylhydrazyl and 2, 2β-azino-bis-3 ethylbenzothiozoline-6-sulphonic acid diammonium salt, IC50 0.65 and 0.62 mg/mL, respectively)} compared to 1 (IC50 0.83 and 1.14 mg/mL, respectively) ($p < 0.05$). Compound 2 recorded no significant difference in DPPH.scavenging activities (IC50 0.65 mg/mL) compared to α-tocopherol (IC50 0.63 mg/mL). Pro-inflammatory 5-lipoxygenase inhibitory activity of 2 was found to be comparable (IC50 0.98 mg/mL) to that displayed by synthetic anti-inflammatory drug ibuprofen (IC50 0.93 mg/mL).

Polyunsaturated fatty acid enriched formulations from locally available low-value fish and fishery by-catch for use as nutraceuticals and aquafeed supplements

Research project: EFP-18

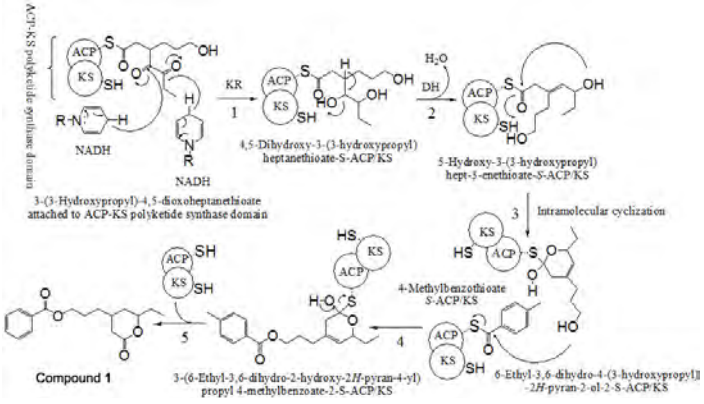
Changes in the quality of refined fish oil in an accelerated storage study

Refined sardine oil showed greater susceptibility towards oxidation than the crude oil, but addition of fractions of red seaweeds *Hypnea musciformis, Kappaphycus alvarezii*, and *Jania rubens* significantly increased the oxidative stability. Oxidative stability indices (≥ 0. 51 h) appeared to be higher than α-tocopherol. The induction time for refined oil added with *H. musciformis* (1.26 h) was greater than butylated hydroxytoluene (1.04 h) and α-tocopherol (0.4 h). This demonstrates the potential of seaweeds as natural alternatives to synthetic antioxidants in preventing rancidity of refined fish oil for use in food and pharmaceutical industries.

Characterisation of Polysaccharides and Phenolics from Marine Macroalgae as Defense Metabolites against Oxidative Stress and Inflammation

Research project: EFP-17

Unprecedented antioxidative and anti-inflammatory aryl polyketide pharmacophore leads from *Sargassum wightii*: Previously undescribed polyketide lactones, 41-(2-ethyl-tetrahydro-6-oxo-2H-pyran-4-yl) propyl-4'1-methylbenzoate (1) and methyl-31-(12-oxo-7-phenyl-8-vinyl-1-oxa-4, 9-cyclododecadienyl)-acetate (2) were isolated from Sargassum wightii. Antioxidative activities of the lactones were significantly greater ($P < 0.05$) (IC50 1, 1-diphenyl-2-picrylhydrazyl radical scavenging 0.2-0.6 µM) compared with the synthetic antioxidants butylated hydroxytoluene, butylated hydroxyanisole and α-tocopherol (IC50 > 1.5 µM). Additionally, the title compounds displayed potential 5-lipoxygenase inhibitory activity (IC50 1.84 and 0.82 µM, respectively). Putative biosynthetic pathway of the title polyketide products through polyketide synthase enzyme cascade catalysed reactions appropriately substantiated the structural attributions of the hitherto unreported aryl polyketides.



Schematic representation of the putative biosynthetic pathway of polyketide

Antioxidative sulfated polygalactans from marine macroalgae as angiotensin-I converting enzyme inhibitors: Antioxidant and antihypertensive potential of sulfated polygalactans isolated from the marine macroalgae *Kappaphycus alvarezii* and *Gracilaria opuntia* were assessed by utilizing different *in vitro* systems. The sulfated polygalactan → 4)-4-O-sulfonato-(2-O-methyl)-β-D-galactopyranosyl-(1→4)-3,6-anhydro-(2-O-methyl)-α-D-galactopyranan from *K. alvarezii* showed greater angiotensin-I-converting enzyme (ACE)

inhibitory activity (IC_{50} 0.02 µg/mL) than →3)-4-O-sulfonato-(6-O-acetyl)-β-D-galactopyranosyl-(1→4)-3,6-anhydro-(2-O-sulfonato)-α-D-galactopyranosyl-(1→3)-4-O-sulfonato-(6-O-acetyl)-β-D-xylosyl-(1→3)-4-O-sulfonato-(6-O-acetyl)-β-D-galactopyranosyl-(1→4)-3,6-anhydro-(2-O-sulfonato)-α-D-galactopyranan motif extracted from *G. opuntia* (IC_{50} 0.70 µg/mL).

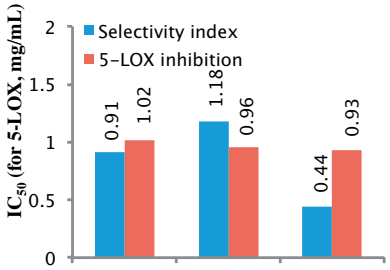
ICAR-CRP on Health Foods

Research project: EFP-19

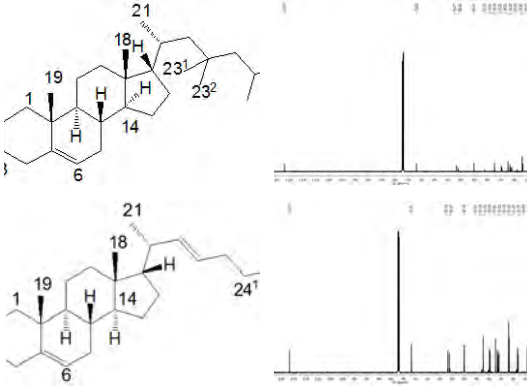
New sterols with anti-inflammatory potentials against cyclooxygenase-2 and 5-lipoxygenase from *Paphia malabarica*: Antioxidant and anti-inflammatory-guided purification of bioactive compounds from *P. malabarica* characterised two new sterol derivatives as 23-gem-dimethyl-cholesta-5-en-3β-ol (1) and (22E)-241,242-methyl-dihomocholest-5,22-dien-3β-ol (2). The antioxidant and anti-inflammatory activities of 2 as determined by DPPH/ABTS+ radical scavenging and anti-cycloxygenase-2/5-lipoxygenase assays were significantly greater (IC_{50} < 1 mg/mL) than 1 (IC_{50} > 1 mg/mL). This is the first report of the occurrence and characterisation of 23-gem-dimethyl-3β-hydroxy-Δ5-cholestane nucleus and C-30 dihomosterol from marine organisms.

First report of two antioxidative meroterpeno 2H-pyranoids from *P. malabarica* with bioactivity against pro-inflammatory cycloxygenases and lipoxygenase: Two new meroterpeno 2H-pyranoids were isolated from *P. malabarica.* The extended C18 sesquiterpenoid with prenylated irregular farnesene framework was characterised as 2-((E)-deca-1,8-dien-10-yl)-11,12-dihydro-13-propyl-2H-pyran (1). The compound 2, 1'-(10E)-10-(10-(pentan-4-yl)-cyclohex-4-enyl)-allyloxy)-tetrahydro-2',2'-dimethyl-2H-pyran represents the first example of naturally occurring C21 prenylated bisabolene type meroterpenoid, whereas tetrahydro-2',2'-dimethyl-2H-pyran remains attached at C-2' position of rearranged bisabolene framework formed by allyloxy linkage. The antioxidant activities (DPPH/ABTS+) of 1 and 2 were comparable (IC50α-tocopherol. In addition, these compounds exhibited greater activity against cycloxygenase-2 (COX-2) than COX-1, and the selectivity indices were significantly lesser (~1.1). No significant differences in anti-5-lipoxygenase (5-LOX) activity of 1 and 2 (IC_{50} 1.02-1.06 mg/mL) than ibuprofen (IC_{50} 0.93 mg/mL) indicated the potential anti-inflammatory properties of title compounds.

New sterols with anti-inflammatory potential



	Selectivity Index	5-LOX inhibition (mg/mL)
1	0.91	1.02
2	1.18	0.96
Ibuprofen	0.44	0.93

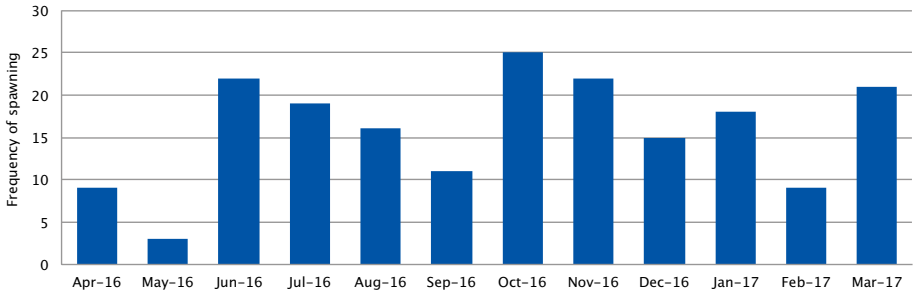


Broodstock and seed production

Research Project: FISHCMFRISIL201202400024

Orange spotted grouper *Epinephelus coioides*

Round the year breeding of orange spotted grouper was achieved with 22 brooders (10 sex reversed male and 12 female) stocked in re-circulatory system (RAS) of 125 t capacity at Visakhapatnam RC of CMFRI. The spawning frequency varied from 3 to 25 times in a month. The minimum spawning frequency (3) was found to be in the month of May 2016 and maximum spawning frequency (25) was found in October 2016.



Spawning frequency of orange spotted grouper stocked in re-circulatory tank

Standardisation of larval rearing protocol

Trials were conducted to improve larval survival by manipulating feeding protocol and environmental parameters during the larval rearing of orange spotted grouper, *Epinephelus coioides*. The survival rate during the larval rearing was improved and a highest survival of 12.57 % was achieved. A total of around 25, 000 metamorphosed fingerlings were produced during the reported period.

The hatched out larvae were stocked @ 10 nos. per liter in 2 t capacity tank. Copepod of different species (*Acartia spinicauda*, *Parvocalanus arabiensis* and *Oithona nishidai*) were added to rearing tanks @ 60 no per liter. The microalgae *Isochrysis galbana* and *Nannochloropsis oculata* (1: 5 ratio) was added to the larval raring tank from 0 DPH @ 1x 10^4-10^5 cells/ml. The rotifers were provided from 2nd DPH @ 10 nos/ml till 25th DPH. The Artemia nauplii were provided from 18th DPH and artificial feed were introduced from 14th DPH onwards. The larval metamorphosis started from 27th DPH and completed by 35th DPH. The metamorphosed fingerlings were fully weaned on the artificial diet by 35th DPH. The grading was performed 3 times on every 5 days starting from 30th DPH to reduce cannibalism.

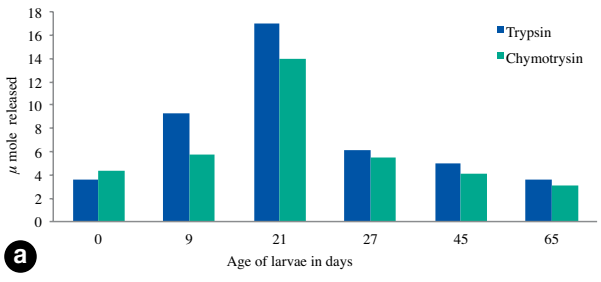
Digestive enzyme activity in grouper larvae at different stages of development

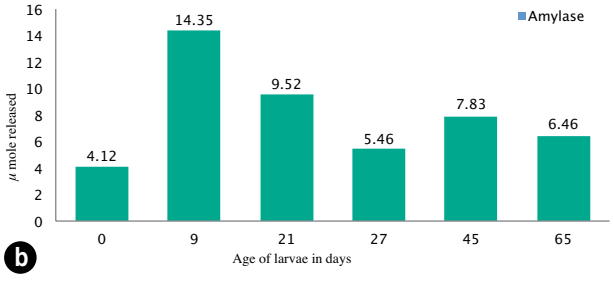
The different digestive enzymes such as amylase, trypsin, chymotrypsin and lipase were estimated during the different stages of larval development. All estimated digestive enzymes were significantly less at 0 DPH (newly hatched larvae). The amylase showed increasing trend till 9th DPH then started decreasing. Trypsin and Chymotrypsin was found to be maximum on 21st DPH then started decreasing. Lipase showed maximum activity on 27th DPH then started decreasing however its activity never gone below the 0 DPH level during the entire experiment.

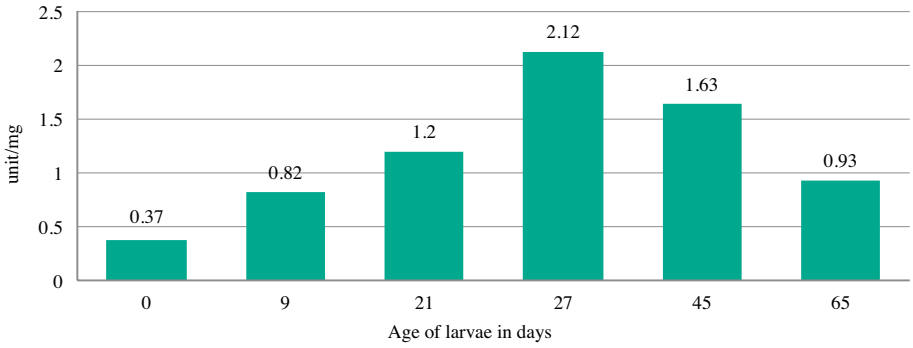
Nursery rearing of orange spotted grouper (*Epinephelus coioides*)

Nursery rearing of early fingerling stages of orange spotted grouper was conducted in hapas installed in concrete tank at Visakhapatnam Regional Centre of CMFRI. Fingerlings (average size of 4.2 cm in length and 1.5 g in weight) were stocked at the stocking density of 100 numbers

a. Trypsin and chymotrypsin activity in grouper larvae at different stages of their development
b. Amylase activity in grouper larvae at different stages of their development







Lipase activity in grouper larvae at different stages of their development

/m^3 in 0.6 mm mesh nylon net. Different feeds like minced meat (minced fish meat and shrimp meat), artificial feeds with different protein levels (45 & 50%) and combination of artificial feeds and fish meat were used. Feeding was done four times in a day @ 10% of body weight. After two months of rearing in nursery phase, Different growth parameters were calculated and shown in the table. The weight gain of fingerlings has shown significant difference among all the treatments. However, the higher growth was observed from the treatment with the combination of minced meat and artificial feed at 1:1 ratio.

Cobia, *Rachycentron canadum*

During 2016-17 a total of six spawning inductions of cobia were carried out and among these inductions four were carried out in tanks with recirculating aquaculture system (RAS) and two in the spawning tanks without RAS. The eggs per spawning ranged from 0.5 to 5.8 lakhs and

Treatments	WG %	SGR	FCR
FM	205.64a±1.04	1.74a±0.10	3.11d±0.26
FM+50%	961.00f±1.00	3.97d±0.03	1.32a±0.02
Acetes+45%	837.29e±1.29	3.66c±0.08	2.13b±0.04
Acetes+50%	686.19d±0.48	3.42c±0.02	2.68c±0.05
50%	558.36b±2.36	3.06b±0.09	3.27d±0.11
Artemia biomass	478.36c±2.35	2.87b±0.06	4.21e±0.04

the fertilisation rate varied from 86.2 to 87.1 %. The hatching percentage ranged from 58.8 to 66.1. A total of 5500 cobia fingerlings were produced and to farmers, fishermen and research institutions for farming and field demonstrations. Lower survival rate during larviculture could be attributed to the low water temperature in the larviculture tanks.

Silver Pompano, *Trachinotus blochii*

Six spawning inductions were carried out in silver pompano during 2016–17 and fertilised eggs were obtained in four spawning. The total number of eggs per spawning ranged from 1.05

S. No	Date of experiment	No. of eggs (lakhs)	Fertilisation per cent	Hatching per cent	No. of larvae used for fingerling production	No. of fingerlings produced
1	17/06/2017	No spawning resulted	—	—	—	
2	16/11/2016	5.3	87.1	66.1	1.0 lakh	2000
3	22/12/2016	No spawning resulted	—	—	—	
4	06/01/2017	0.5	Unfertilized	—	—	—
5	10/02/2017	5.8	86.2	58.8	1.0 lakh	3500
6	12/02/2017	No spawning resulted	—	—	—	

to 2.46 lakhs. The fertilisation rate ranged from 69.3 to 93.8 per cent and the percentage of hatching ranged from 76.7 to 92.1. A total of 19370 silver pompano fingerlings were produced and supplied to farmers, fishermen and research institutions for farming and field demonstrations.

Broodstock development of silver pompano (*Trachinotus blochii*) in sea cages

Sub-adults of hatchery produced silver pompano (150 nos.) are being maintained for broodstock development in HDPE sea cages of 6 m diameter. The body weight of sub-adult pompano ranged from 1.2 to 2.0 kg. Another batch of 600 Nos. of silver pompano fingerlings weighing

S. No	Date of experiment	No. of eggs (lakhs)	Fertilisation per cent	Hatching per cent	No. of larvae used for fingerling production	No. of fingerlings produced
1	20/11/2016	1.47	69.3	92.1	93990	5270
2	23/12/2016	1.05	93.8	76.7	75955	6500
3	04/01/2017	No spawning resulted	–	–	–	
4	30/01/2017	No spawning resulted	–	–	–	
5	01/03/2017	2.46	78.8	83.2	161411	7600
6	20/03/2017	No spawning resulted	–	–	–	

125 – 220 grams size are being reared in a separate 6meter dia HDPE cage. All the silver pompano sub adults and juveniles are fed with fresh low value fishes, squid and flesh of crabs @ 3 – 8 % of their body weight. Periodic monitoring of growth and health parameters are being carried out. The broodstock development is in progress.

Mangrove Jack *Lutjanus argentimaculatus*

Mangrove Jack *Lutjanus argentimaculatus* adults were collected, stocked and being reared in cages. During the reporting period almost all the fishes have attained sexual maturity. The Male attained sexual maturity at 2.7 Kg and Female attained at 3.1 Kg. The potential brooders were brought into the hatchery and maintained under environmentally controlled conditions. Specific maturation feeds were given along with vitamin, mineral and immunostimulants. Regular ovarian biopsy studies were carried out and gonadal maturation status was studied. Once the Oocytes attained the desired size spawning trials were attempted. Successful

a. Cobia fingerlings ready for supply
b. Supply of cobia fingerlings to farmers
c. Supplying silver pompano seeds to ADAK
d. Supplying silver pompano seeds to farmers

spawning was obtained and fertilised eggs were collected and stocked in the egg incubation tanks. Embryonic development was arrested in early embryo stage.

Seed production and larval rearing of Green Tiger Shrimp (*Penaeus semisulcatus*)

Green tiger shrimp, *Penaeus semisulcatus* brooders were collected through the trawlers operating along Gulf of Mannar. The brooders size ranges from 37.0g to 64.4grams. Six numbers of brooders were released into 150 litres spawning tank filled with sea water. EDTA was added @ 1mg/L as chelating agent in the spawning tank. Spawning success was observed in five numbers of brooders. The total nauplii obtained was estimated as 5,36,500 by volumetric method. After spawning nauplii were transferred to 5 ton capacity larval rearing tanks. Larvae from protozoea I to Mysis III were fed with *Chaetoceros* spp. Post larvae 1 to post larvae 20 were fed with combination of rotifer, Artemia nauplii and encapsulated larval feed. All the larval stages were observed under microscope for analyzing health and feeding status. Water quality parameters were also monitored periodically. Water exchange was carried out from 20 – 40% on daily basis. Total of 2,41,300 post larval shrimp (PL20) was obtained and a final survival of around 10,000 shrimps were raised up to the size of 10-13 grams in cement tanks within a period of 5months.

Mysis

Mysis

Post larva

Breeding and seed production of marine ornamental fishes

Broodstock development of commercially important marine ornamental fishes namely *Pseudanthias squamipinnis*, *Amphiprion frenatus* are under way. Additional pairs were developed for scaling up of seed production of *A. ocellaris* and *A. percula*. Further, scaling up of seed production of *Amphiprion percula* and pink skunk clown are being carried out. The hybrid clown fish varieties viz., Platinum, Snow flake and Picasso clown fishes were also successfully bred and seed production is in progress. An amount of ₹ 5.75 lakhs was generated as revenue through sale of marine ornamental fish fingerlings and remitted under the ICAR Mega Seed Revolving Fund account as well as ICAR revenue generation account.

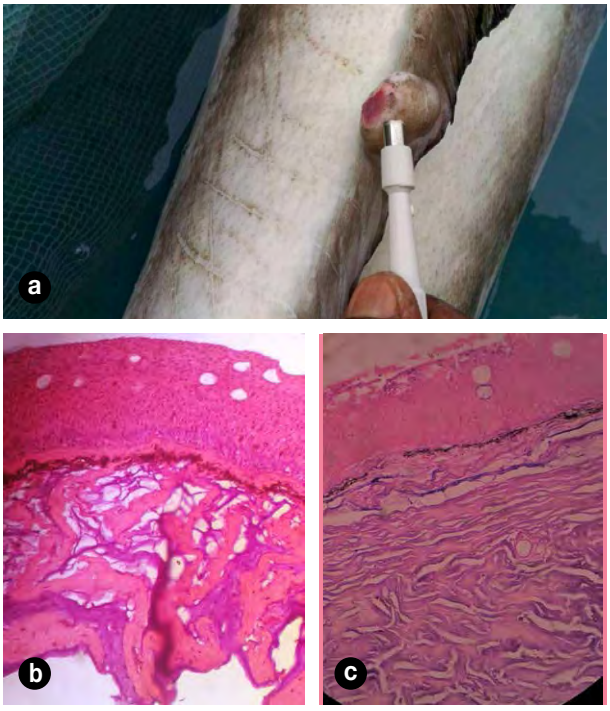
Disease monitoring and health management of fish broodstock of cobia and pompano

Rhabdomyoma: Tumour in cobia

There was a case of hard circumscribed localised swelling noted at the ventral anal fin of the cobia sub-adult (male). The swelling was absent during the fingerlings stage which was reared in the hatchery system. A sudden appearance of the mass at the anal fin implicated a special attention to diagnose the localised mass. A punch biopsy 5.5 mm dia was taken from the mass and it was fixed in 10% neutral buffered formalin for the histology. The inner part of the mass revealed pearl shaped circular muscle structure. The myocytes were hyperchromatic and the muscle fibres lost their cross striations. In some portion, there was bundles of collagenous structures replaced the normal muscular structures. Based on the histological features, the muscle mass was the Rhabdomyoma. It was a tumour of striated muscle and was reported only in few species of fish. Most were well circumscribed, greyish white, firm masses in the trunk muscles. They were composed of irregularly grouped, elongated muscle cells with or without cross striations in the cytoplasm. This was one of the benign neoplasm localised in the anal fin of the cobia sub-adult.

Exophthalmos in silver pompano due to *Bacillus* sp. infection

Sudden mortality of pompano fingerlings was noticed during March 2017. The fingerlings were reared in FRP tanks. Grossly there were no external lesions, but in all the fishes both



a. Localised circumscribed tumour mass at the anal fin
b. Cobia Skin: Normal epidermis and distorted serosal layer. H&Ex400x
c. Cobia Stratum campactum Wavy appearance admixed with the melanin pigments. H&Ex400x

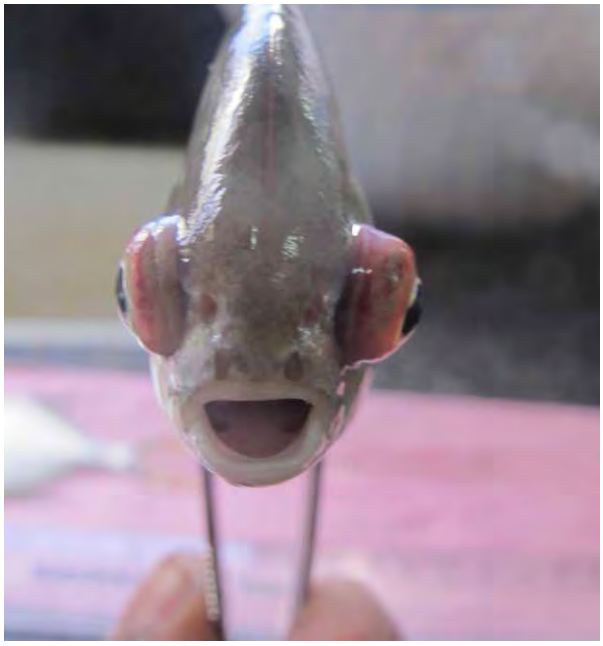
the eye balls were lost. The Moribund fishes showed exophthalmos of both eyes with severe congestion. The redness and congestion of the eye might have attracted the other healthy fish to attack the affected one. Isolation from the heart blood and kidney showed Gram's positive, rod shaped organism. Based on the cultural and biochemical test, the causative organism of the infection was identified as *Bacillus* sp.

Development of inactivated whole cell bacterial vaccine and testing of its efficiency of antibody titre by ELISA

The goal of vaccination is to stimulate the acquired immune system to form B cells and memory B-cells. The memory cells produce additional antibodies if the animal is exposed to the antigen again, for continuation of protective immunity over time. Similarly, T-cells will also form a memory towards antigens presented in cell mediated immunity. A vaccine trial was conducted in three groups of cobia fingerlings (n=10) namely vaccine (Group I) adjuvant alone

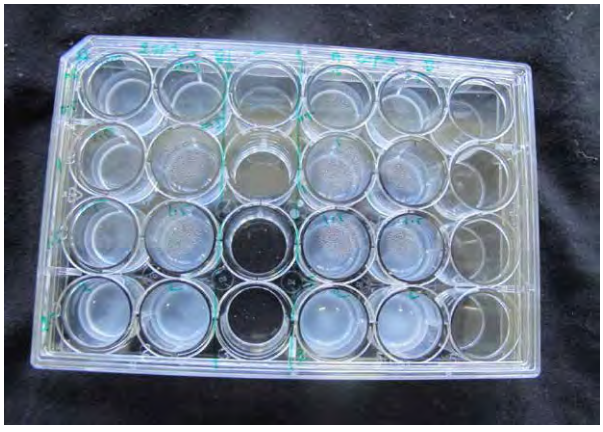
Pompano fingerlings with severe congestion of the eye with exophthalmos

(Group II) and control (Group II). Since the fingerlings transferred to the sea cage system are susceptible to vibriosis, it was decided to vaccinate them at this age. Initially, it was planned to test the efficacy of vaccine for 42 DPV (Days of Post Vaccination). In this trial, there was a significant increase in the OD values of serum antibodies till 21st day which dropped by 42 DPV. When the vaccinated fish were challenged on 42 DPV, no mortality was recorded. However, the vaccinated and challenged fish showed clinical signs of darkening of skin, reduced feeding behaviour and surfacing. Affected fish recovered without any treatment. All the control (PBS) and adjuvant control fish succumbed to the challenge infection in 48 h. The OD values of serum antibody level significantly increased till 14 DPV, dropped from 21 DPV and reached the control level at 42 DPV. On challenge, the antibody titre increased at 35 DPV indicating infective titre. Serum antibody OD levels level has been showed increasing trend during 7,14 and 21st DPV and the antibody levels were maintained up to 42 DPV.

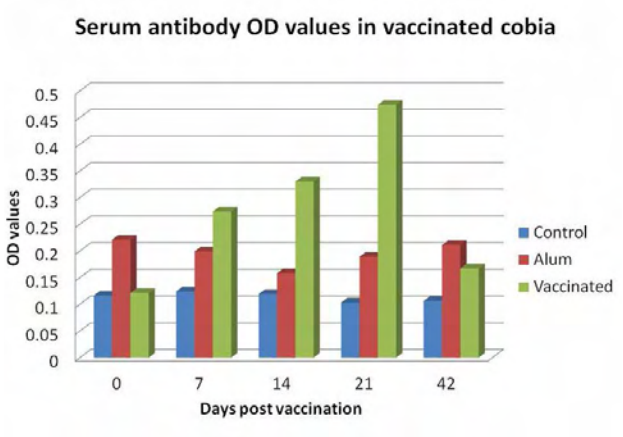


Bilateral Exophthalmos

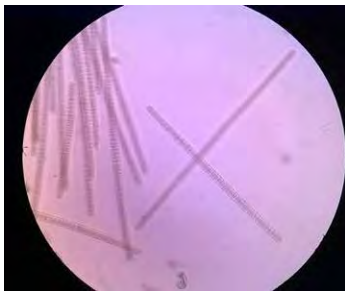
Administration of vaccine by intra-abdominal route (0.2ml)



Adjuvant and antigen adsorption estimation



Graph: Serum antibody OD values in cobia with inactivated vaccine



Trichodesmium sp. (the bloom species) under microscope

Incidence of mass mortality in the sea cage farm of Mandapam Regional Centre

A harmful algal bloom (HAB) of *Trichodesmium* species occurred adjoining the sea cage farm of the Centre. Water samples from the shore as well as the cage sites were collected to confirm the bloom species and to estimate the water quality parameters. The microscopic examination of the water samples confirmed the algal species to be *Trichodesmium* sp. The sea cages holding brooders of cobia were severely affected by the HAB and a heavy mortality of brooders occurred. The mortality had occurred only in cobia not in other species of fishes which might be due to the fact that cobia, being the fast growing fish with very high metabolic rate, has very high oxygen demand and is highly sensitive to low dissolved oxygen. The Silver Pompano is highly resilient and survived the occurrence.

Patchy scum formation of the bloom only very near to the shore

Dead brooders of cobia

Details of the mass mortality and stock position of brooders in sea cages during harmful algal bloom (HAB)

Cage No.	Species	Kind of fishes	Stock position (nos.) before HAB	Average weight of each fish (kg)	Total Biomass (kg)	No. of fishes died due to HAB	Stock Position (nos.) after HAB	Percentage of mortality
1	Cobia	Brooder-1	22	30	660	16	6	72.7
2	Cobia	Brooder-2	26	28	728	20	6	76.9
3	Cobia	Brooder-3	34	20	680	26	8	76.4
4	Cobia	Brooder-4	36	15	540	36	Nil	100
5	Silver Pompano	Brooders	35	2.5	87.50	2	33	5.7

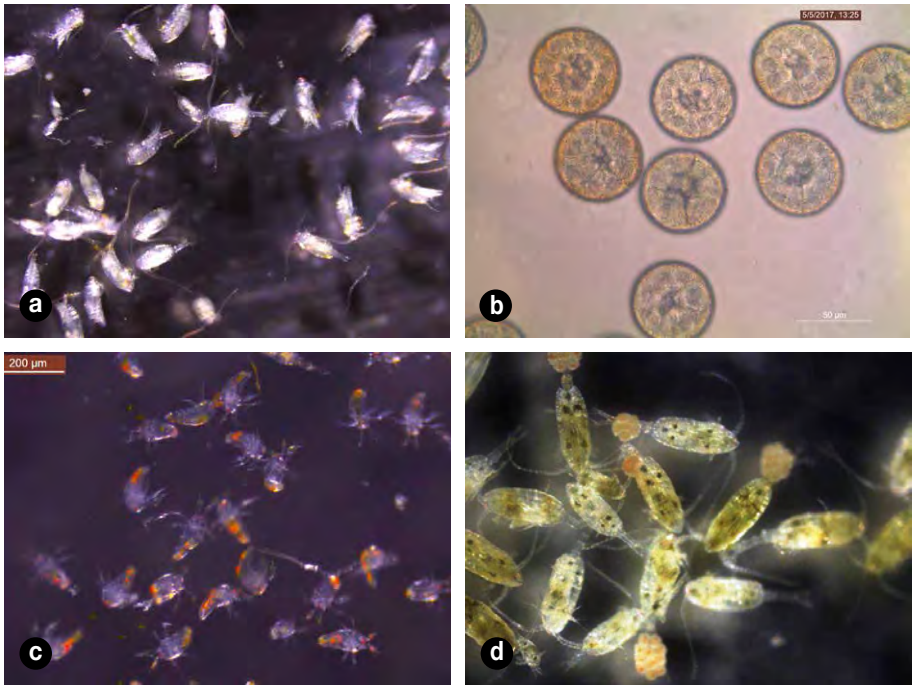
Investigations revealed that low dissolved oxygen concentration at the peak of bloom and during mortality observed in the present case, might be a possible factor for the mass mortality. Efforts are being taken to collect sub-adults/brooders of cobia from the wild to rebuild the broodstock numbers. Arrangements were made at Amalinagar and Muttom in Tamil Nadu and Vizhinjam in Kerala for collection of cobia sub adults from the wild.

Live feeds

Mass culture of five species of calanoid copepods as promising live feed suitable for finfish larviculture

Vizhinjam Research Centre of CMFRI has developed stock and mass culture protocols for five promising calanoid copepod species, *Temora turbinate*, *Pseudodiaptomus serricaudatus*,

Acartia spinicauda and *Parvocalanus arabiensis*. Among these *P. serricaudatus* produce egg sacs. All other species scatter their eggs in the bottom of the culture tanks and eggs and nauplii can be harvested. First two naupliar stages of all these species ranges from 95-120µm except for *P.arabiensis*. P. arabiensis has initial naupliar stages with size less than 50µm. Hence this is very useful for feeding very small fish larvae like that of groupers and damsels. *P.arabiensis* grow well in a feed mixture of *Nannochloropsis salina* and *Isochrysis galbana*. This species possess all the essential qualities of an ideal feed for hatchery. *P.arabiensis* is hardy, tolerant to wide range of salinity and temperature. This is a prolific species with



a. *Parvocalanus arabiensis*
b. *Parvocalanus arabiensis* eggs
c. *Parvocalanus arabiensis* naupliar stages (live)
d. *Pseudodiaptomus serricaudatus*

very short period it can reach higher density than most of the other copepods. Calanoid copepods generally occupy the entire water column evenly and hence these are available near to the week larvae.

Copepod culture and nauplii harvesting technique

The three species suitable for initial feeding for grouper larvae namely: two species of Calanoida; *Acartia spinicauda*, *Parvocalanus arabiensis* and one species of Cyclopoida; *Oithona nishidai* were used for the culture and produce their nauplii. The nauplii size of these three species is less than 60 µm. These copepod species were cultured in 5 t capacity tank. They were fed with different combination of phytoplankton such as *Nannochloropsis oculata*, *Isochrysis galbana*, *Chaetoceros calcitrans*.

A model was prepared and used for harvesting nauplii from copepod culture without harvesting adult copepod. A tank of 300 l capacity was used for copepod culture and harvesting nauplii. A mesh of 125 µm was fixed above the tank bottom (10 cm) for passing out the copepod nauplii and eggs. The tank bottom was connected with a PVC pipe is such a way that the water containg nauplii and eggs get lifted up to the top of the tank. The over lifted

water is passed through the 40 µm filter so that the feed as well as water pass through the mesh and go the same tank and nauplii and eggs get collected in 40 µm filter. The tank was stocked @ 200 nos. adult copepod per liter. The copepod was fed with mixture of different phytoplankton i.e. *Nannochloropsis oculata*, *Isochrysis galbana*. The nauplii and eggs were collected morning and evening to feed the larvae. This system is good enough to collect 1 lakh nauplii per collection time.

Transportation trials of hatchery produced Orange spotted grouper

Fingerlings of orange spotted grouper (1.3 – 5g gm size) can be transported at stocking density of 5, 10, 15 and 20 nos. per liter of water for 24 h without any mortality. When fingerlings of size 0.8-1.0 g were packed in plastic packet at stocking density of 25, 50, 75 and 100 nos per liter of water mortality was started after 4 h of packing in the treatment with highest stocking density (100no/lit), and rest of the groups could achieve 100% survival after 24 h. Fingerlings stocked in 100 nos per liter after four hours has shown lowest alkalinity (87.5 mg/l) coupled with lowest pH (6.87) and highest carbon dioxide (4.45 ml/l) significantly higher level of tissue glucose (188.02±0.001), glutamic oxaloacetic transaminase (GOT; 6.18±0.08), glutamic-pyruvic transaminase (GPT; 8.86±0.19) and Lactate dehydrogenase (LDH; 5.61±0.06).

ICAR mega Seed Project

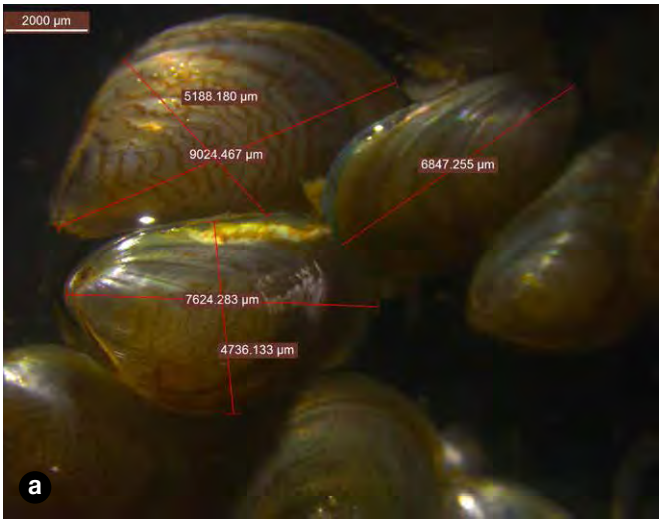
Marine ornamental fishes such as *Premnas biaculeatus*, *Amphioprion ocellais*, *A. percula*, black percula *A. sebae*, *A. sandarocinos*, *A. frenatus*, *A. nigripes*, *A. clarkii*, and hybrid varieties Platinum, Picasso & snow flake were produced under captive conditions in this project. Micro algae such as *Chaetoceros calcitrans*, *Navicula* sp., *Chlorella marina*, *Pavlova lutheri*, *Chlorella* (FW), *Skeletonema* sp., *Dunaliella salina*, *Spirulina platensis*, *Isochrysis galbana*, *Synechocystis* sp., *Nannochloropsis oculata*, *Thalassiosira* sp., *Nitzchia* sp. and *Tetraselselmis* sp., were also produced. These captive produced ornamental and algae were sold in a single window system to the farmers from all over India, and revenue ₹4,49,872 were generated during the financial year 2016-2017.

Bivalves: spat production and rearing

Successful mass production of green mussel *Perna viridis* was achieved and 2 million seeds were produced. The seeds were supplied to the farmers in Perumathura and Kavanadu.

A rectangular framed cages for nursery rearing of green mussel spat was designed.

a. Green mussel spats
b. Hatchery produced mussel seed



Preparation of wooden rack for oyster farming at Naluvathucherry

Broodstocks of edible oyster *Crassostrea madrasensis* were maintained and spawned with thermal stimulation and spats were set on oyster shells which were supplied to the farmers for rearing. The average spat attachment number was 4-5/shell with a size range of 1.5 to 2 cm.

Gastropods

Spawning and rearing results

Continued brood stock maintenance of Strombids (*Lambis lambis*), Cyprids (*Cypraea tigris*) and Muricids (*Chicoreus ramosus*) over the years resulted in repeated spawning confirming the standardisation of protocols. Details of the brood stocks are given in table below

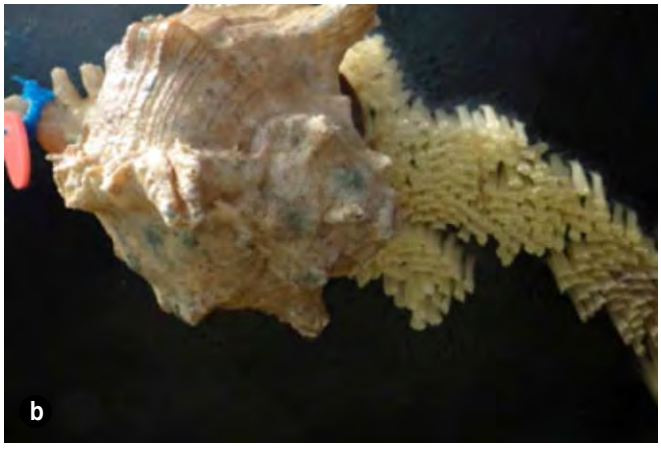
Strombid (*Lambis lambis*)

Several cylindrical white to pale brown coloured egg filaments were released which attaches to the seaweed/stones provided in the rearing tanks. In the translucent tubular filament, spherical shaped embryos were found arranged in double rows. The egg diameter ranged from 1562 to 1652 µ. The hatched veligers could be reared for two weeks.

Muricid (*Chicoreus ramosus*)

The growth of the larvae was standardised and the pre juvenile production rate in the rearing trails ranged from 8.8 to 25%. Details of the spawning is given in table below.

a. Egg coils of *Lambis lambis*
b. Spawing in *Chicoreus ramosus*



Cyprid (*Cypraea tigris*)

The brooders of *Cypraea tigris* were fed with ad libidum diet of the microalgae *Ulva* sp. These algae encrusted stones were replaced with fresh ones after the feeding. The average feed requirement for maintenance of brooders was worked out to be 18g per brooder.

Feeding protocol for gastropod brood stock

Parameter/species	*Lambis lambis*	*Chicoreus ramosus*	*Cypraea tigris*
Feed	*Chaetomorpha* sp. & *Ulva* sp.	Clam meat	*Chaetomorpha* sp. & *Ulva* sp.
Feeding rate (g/brooder/day)	18	2	18

Brood stock management

Species	Numbers of brooders maintained	Period of maintenance (in years)	Stocking density (nos/ ton)	Sex ratio	Size range (mm)	Weight range (g)	Rate of survival (%)
Lambis lambis	30	>2	10	1:1	132-169 (146)	259–424 (320)	100
Chicoreus ramosus	30	>2	10	Unsexed	168-205 (182)	693-1255 (970)	100
Cypraea tigris	20	>1	20	Unsexed	73-89 (77)	166-256 (207)	100

Growout technologies

Research Project: FISHCMFRISIL201202500025

Cage culture technology for both finfish and shellfishes were popularised through demonstrations and imparting hands on trainings to farmers along east and west coasts of India. Demonstrations and trainings were done in association with many fishermen SHGs and state government agencies.

Indigenous and innovative technologies like GI steel circular cages of different sizes, rectangular, battery type cage for finfish and iron frame net cages, FRP rectangular floating cages for shell fishes developed by various centres and demonstrated to the fishermen. The finfish and shell

fish farmed in cages during this period includes Asian seabass, cobia, pompano, snappers, lobsters and crabs.

Veraval

Demonstration programmes of cage farming along the Kutch coast has been progressing successfully with the involvement of selected fishermen groups. Lobsters were stocked in two square GI cages @1000 numbers per 6 x 6m cages. The survival rate was 88.94 % without any disease or infections. The salinity during the stocking period was 35 ppt and the prevailing temperature during day time was 32°C and during night was 27°C. Average growth of lobsters was 1.12g/day in the cages. They were fed with chopped trash fish at a rate of 10% of their body weight.

Along the Mandovi coasts of Gujarat indigenous low cost square bamboo cages were fabricated and deployed by several individual fishermen in the salt pan inlet creeks. The cages vary in sizes depending on the depth and width of the channels. The cage dimensions ranged from 1 x 2x 2m to 2 x 3 x 3m. Discarded fishing nets of appropriated mesh size or new hapa nets were used in cages. The cages were stocked with either lobsters or with various finfish seeds collected locally. The finfish seeds comprised of various species of seabreams. The fishes were fed with chopped trash fish or fresh acetes ad-libitum two times a day.

Open sea cage farming was initiated at Mangrol, Veraval and Okha areas along Gujarat coast by fishermen groups and entrepreneurs selected by State fisheries department with the technical support of Veraval Regional centre of CMFRI. The site selection process and the trainings for the selected fishermen were completed. The cage fabrication is in progress.

Karwar

Cage culture of Asian seabass in 6 m dia. steel cages at Karwar was undertaken during 2016-17. Fishes were transported from RGCA, hatchery and nursery reared in Marine hatchery complex of Karwar for one month. Fish with an average weight of 30 g were stocked in two 6 m dia. steel cages with a density of 11 numbers per m^3. Fishes were harvested with an average final weight of 1.5 kg after eight months of culture.

Cage culture of Pompano was undertaken at Karwar in 6 m dia. steel cage with an initial stocking density of 10 numbers/m^3. Fish were fed with oil sardine @6% biomass throughout the culture period. Fishes were harvested with an average weight of 0.5 kg after 360 days of culture.

In order to increase the production and maximizing the profit, farming experiments using 10m diameter HDPE cages were initiated at Karwar. Four 10 m HDPE cages were installed and stocked with seabass and pompanos. Farming trials are progressing

Goa

Cage culture of Sea bass, cobia and pompano was carried out at Polem, Goa. Farming was done in a participatory mode by Self Help Groups. Site selection and technical advices on cage designing, installation and farming were done under the technical support from Karwar research centre of CMFRI. Trainings were organised to empower members of self-help group to take the farming activities. An harvest of 11 tonnes of Asian seabass were made from from 6m dia. steel cages.

Mangalore

Farming technology for estuarine farming was successfully developed and demonstrated. Viable cage designs for small scale cage culture in estuaries of Karnataka were standardised and popularised. Feasible techniques for floatation, cage installation and cage mooring in estuaries were tested and standardised.

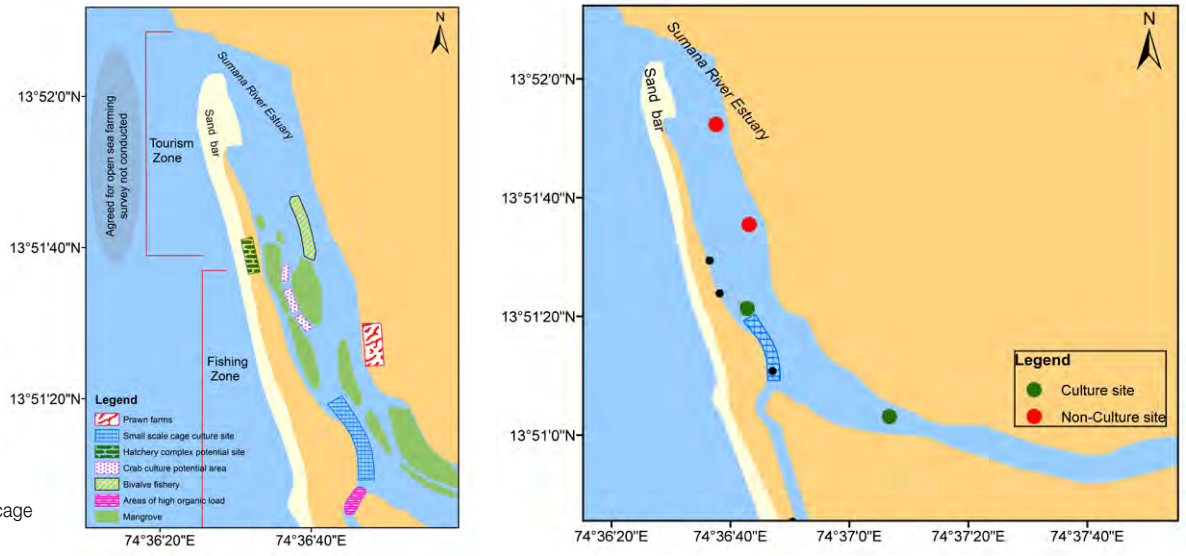
Growth of Seabass and Red snapper in estuarine cages

Two years continuous rearing experiments to monitor the growth of seabass in cages were done. Feeding was about 5% of the body weight from 100g onwards. Sea bass reached a weight of 1kg in 10 months, 2 kg in 14 months and 3 kg in 18 months. Second year weight gain was very rapid and it is advocated to rear the fishes for two years for better profit from cages, if the environmental conditions are favorable.

In case of red snapper also second year weight gain was comparatively higher than the first year. Fishes gained a weight of 1kg in 13 months, 2 kg in 18 months and 3 kg in 22 months.

Horizontal expansion of technology in different estuaries like Upunda Creek, Alvekody, Netrvathi

Cages in Alvekody estuary, Karnataka.



GIS mapping of cage culture sites

and Sambavi estuary facilitated. From 5 cages in 2009, it has increased to more than 130 cages in different estuaries of Karnataka.

Consistency in economic feasibility of small scale estuarine cage farming was demonstrated and Government support was facilitated to the farmers. Economics of cage fabrication was documented. The cost and benefits of small scale cage culture operation for one year crop period and for two year crop period were prepared and the recommendations were submitted to the State Government for the phases where the Government support is needed. Recommendations submitted to Government of Karnataka were accepted and the fishermen are getting subsidies in seed and feed upto ₹ 40,000 per cage.

GIS based spatial planning was introduced for site selection of estuarine farming

Identification of different culture site: Area for fishing, cage farming, crab farming, shrimp farming, bivalve farming and tourism were mapped in GIS plat form

Calicut

Delineating the compensatory growth pattern in stunted fingerlings of Marine finfishes for production enhancement

Silver pompano fingerlings (1.5") Procured from Rajiv gandhi Cenre for Aquaculture, Pozhiur, Trivandrum were used for stunting trial. The fishes were stocked in two cement tanks (5 m^3) @ 100 fishes per m3 and reared by providing artificial feed twice daily @ 2.5 % of their body weight for stunting growth. The tanks were provided with sufficient aeration and water exchange (20% of volume) was carried out on alternate days. The fishes could be stunted for 21 days afterwards sudden mortalities were observed due to overcrowding. The weight gain in three weeks was 0.59 g

The experiment indicated that the fishes need to be maintained at a lower stocking rate for stunting process since the species is sensitive for overcrowding. The fishes showed only minimal growth indicating the process of retarded growth.

Growth parameters

Doc	Length	weight
0	3.62 +0.041	0.8+0.027
21	4.54+0.044	1.39+0.03

Kochi

Successful farming demonstrations at various places in Kerala led to the adoption of cage farming technology at various districts of Kerala. The cage design developed by CMFRI for

Cage farms in Ernakulam Disrtict, Kerala

Harvest of Pearl spot from a cage

brackishwater farming was adopted by farmers and fishes like seabass, snappers, carangids, pearl spot and tilapia are being farmed by these fishermen groups in cages.

In Ernakulam, “open water cage farming” in brackishwater has been widely adopted by farmers. The PPP mode of farming mainly focuses on fishermen, fish farmers, unemployed youth, scheduled tribes and scheduled castes. The Panchayats adopting cage farming are Mulavukad, Kadamakudy, Narakkal, Edavanakad, Elankunnappuzha, Nayarambalam, Chittattukara, Chendamangalam, Varappuzha, etc. and municipalities include Aluva, Paravur, Maradu, Thrippoonithura etc. are also promoting cage farming in open waters. More than 400 cage farms are in operational in the district under the technical supervision of CMFRI. These cages have potential for producing 120 tonnes of quality fish for human consumption. In Thrissur Dist., Kaipamangalam, Engandiyur and Ethayi are in the cage culture map of Kerala. About 100 farms are there in the district. In Alappuzha, at Vayalar, and Cherthala three groups have adopted cage farming. At Kollam also cage farming has been adopted by farmers.

Farming demonstration at North Parvoor

Two circular cages of diameter 2x3 m and two cages of 6 meter dia at North Paravoor and two square cages at Pizhala were launched for demonstrating the culture of *L. argetimaculatus* and *Lates calcarifer* and *Caranx*. A six meter dia circular cage was stocked with 2000 nos 10 to 12 mm seeds of *L. calcarifier* and partial harvesting were done after 10 months the average growth was 450 to 550 gm. The second harvest was done in the month of December 2016 after 18 months and the fishes reached 3.75 kg to 5.75kg.

Vizhinjam

In Ozhukkuthode area of Thirumullavaram, a demonstration was undertaken for sea cage farming of lobsters in a floating cage. A 4m x 4m floating cage was fabricated using GI pipe

with empty oil barrels as floats in participatory mode with a farmer's group and Quilon Social Service. Farmers were given training on various aspects of cage farming before the start of culture. Lobsters were stocked in the cages with a stocking density of 100 nos/m^3. Average weight at the time of stocking was 70.6g (40-98) and has grown up to 210.2g (185-304) in seven months period.

Cage farming in media

Success of cage farming in kerala brackishwaters was point of attraction for the media of the state. Newpapers and media channels in the state gave wide coverage for the success of cage farming in states through print and visual media.

Lobster stocking at Ozhukkuthode, Kollam


ബിസിനസ് മനോരമ

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കൂടുകൃഷി

സിന്ദാബാദ്

ഇനി മൽസ്യവിപ്ലവം

ജനുവരി 14ന് മാത്രം

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Visakhapatnam

Nursery rearing of orange spotted grouper (*Epenephelus coioides*) with different stocking densities in earthen ponds

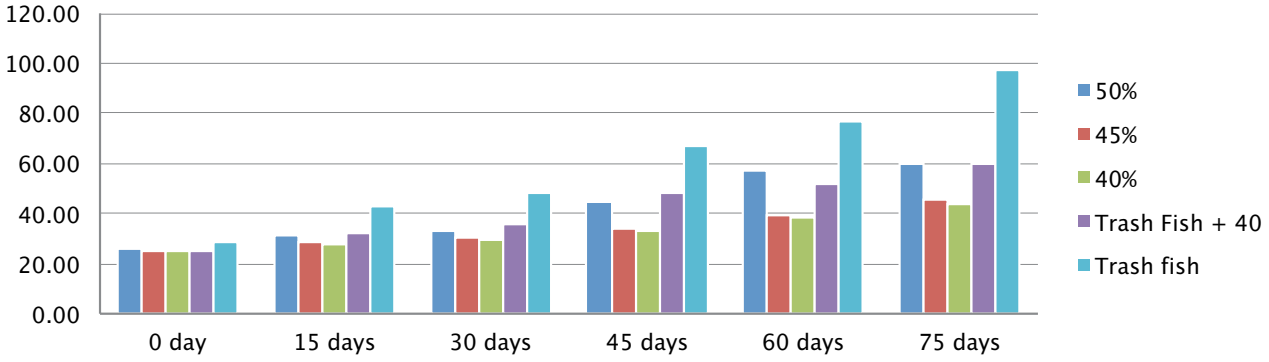
Nursery rearing of hatchery produced orange spotted grouper seeds were experimented in earthen pond in brackish water shrimp pond at 2 places such as Pentakota, Visakhapatnam District and Kothapalem, Krishna District, Andhra Pradesh. In both the places, fishes were released in hapa (1x1x1.5 m) made by 0.6 mm nylon mesh net. Fish fingerlings were stocked at different stocking densities such as 150, 200, 300 & 400. In both the locations the fingerlings were stocked at an average size of 5.64 cm & 3.7 g. At the end of one month of the culture the

stocked fingerlings reached to the size range from 12.5 g to 15.25 g with survival rate up to 93%.

Nursery rearing of wild collected *Trachinotus mookalee* (Indian Pompano) with different feeds

Nursery rearing of wild collected Indian pompono juveniles was carried out at hatchery unit of Regional Centre, Visakhapatnam to observe the growth and feed acceptance. The juvenile fishes were collected from the Visakhapatnam beach by shore seine. Juveniles were acclimatised for pellet feed acceptance and after acclimatisation, nursery rearing of the juveniles started with artificial feeds having different protein levels (32%, 40%, 45% & 50%) and minced fish meat. For each treatment, 30 animals were stocked in 500 lit water in duplicate. The initial stocking size of the fishes ranged from 25 to 29 gram in weight and they fed with respective feeds regularly at 10-12% of body weight. Water quality parameters were maintained same for all the treatments and 100% water exchange were carried out during the experiments. Among all the treatment, the treatment with minced meat showed comparatively higher percentage weight gain (245.31 ±5.86) and SGR (1.65±0.02) and significantly different from other treatments. This study showed that Indian pompono juveniles showed good acceptance for artificial feed with higher protein content and better growth with minced fish meat. The higher growth rate of the fish fed with minced meat also supported by the muscle *Glutamic Oxalacetic Transaminase (GOT), Glutamic Pyruvate Transaminase (GPT)* with significantly higher values 11.34+0.12 & 14.42+0.22, respectively than other treatments.

Growth performance of indian pompano in nursery phase

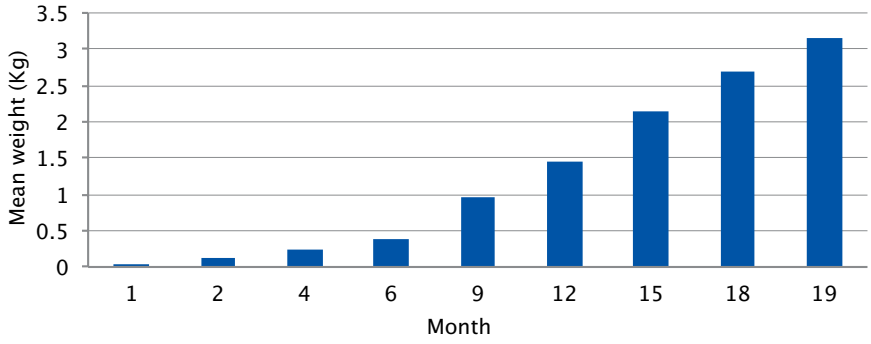


Growth performance of Indian Pompano, *Trachinotus mookalee* in grow-out culture system

Growth performance study on Indian pompano was conducted at Regional Centre, CMFRI, Visakhapatnam in order to evaluate the growth performance of the fish. Fishes were collected from wild in the Visakhapatnam coast at an average size of 42 g. After acclimatisation, they were grown in FRP tanks with artificial feeds till they have reached 250 g. Thereafter they were shifted to RAS (Recirculatory Aquaculture System) and open sea cages, where the fishes fed with clam meat and trash fishes, respectively twice in a day. Growth rate of the fishes were measured periodically and it was observed that the fishes have grown from an average size of 42 g to 3.15 kg in 19 months in both the culture system. The initial study has showed that the fish has got growth potential and the growth potential varies with respect to culture environment.

Cage culture demonstration of Sea bass in creeks at Kuruthuvenu

Cage culture demonstration was carried in creek waters at Kuruthuvenu, Krishna district, Andhra Pradesh. In this site, two GI cages of 6 x 6 m size of square shape were installed with help of barrels for floating and anchors (Iron) and palm tree for mooring. The cages stocked with 600-700 numbers of wild caught seabass seeds at the size varies from 100-150 g. Fishes



Growth performance of Indian pomano during 19 months culture period

fed with trash fish available in the creek. After three month of stocking the fishes reached to the size ranged from 450-575 g. This cage is managed by the single fishermen family using seed and feed source from the creek itself.

Chennai

Participatory cage farming in Kadalur Chinnakuppam

Increased participation from progressive fisher youth has been achieved in cage farming programes through field demonstrations and awareness training programmes. Successful capture-based culture of the mangrove jack *Lutjanus argentimaculatus* was carried out by the fisher youth of Kadalur Chinnakuppam, Kancheepuram district, TN guided by the mariculture team from CMFRI Kovalam, Chennai, in small indigenous low capital fixed cage nets of 3m x 4m x 2m, using low cost and undersized fish caught from the adjacent estuary and coastal waters. The seed, stocked in June 2016, grew to 450-500 g sizes in 6 months and was harvested and sold live @ ₹1000 per kg. The net income earned by the fisher youth in this operation was ₹50,000 from sale of the harvested fish and sale of seeds.

a. Cobia fingerlings in cage
b. Harvested cobia from cage

Pilot-scale cage demonstration

With the initiation of pilot scale demonstration of open sea cage culture by the TN state Fisheries Department under FIMSUL II, with the fisher youth of Kovalam trained through CMFRI's participatory cage culture activities, four GI cages were installed in the sea off Kovalam in April 2016 and stocked with varying densities of cobia as a livelihood initiative.

Mandapam

Sea cage farming of cobia *Rachycentron canadum* in circular HDPE cage

Farming experiments were conducted with 1020 nos. of hatchery produced cobia fingerlings (14.1 cm and 22.7 g) stocked initially in GI cage of 6 meter diameter and 3.5 m depth (0.23 kg per m^3 or 10 fishes per m^3) and as the fish grows they were shifted to a circular HDPE cage of 10 m diameter and 3.5 m depth floated at the sea cage farm in Gulf of Mannar. The stocking density varied during different periods of farming according to their percentage of survival and mean weight of the fishes. The variation in stocking density was 2 kg per m^3 or 4 fishes per m3 with 80% survival after 2 months, 3.8 kg per m3 or 2.5 fishes per m^3 with 70% survival after 4 months and 7.7 kg per m^3 or 2 fishes per m^3 with 60% final survival at the time of harvest.

The fishes were fed with trash fish twice a day during first 3 months and once a day during remaining period @ 3- 5 % of their body weight. A final harvest of 1.715 metric tons was obtained with mean productivity of 6.2 kg per cubic meter farming area in sea.

Successful harvest of sea cage farmed cobia under the State Balanced Growth Fund Scheme for fishermen SHG's carried out with the technical support of Mandapam Regional Centre of CMFRI

The Ramanathapuram district administration of Tamil Nadu under the State Balanced Growth Fund has assisted 10 fishermen Self Help Groups (SHGs) to take up sea cage farming of cobia with 90 per cent subsidy assistance for two cages per group. Hatchery produced 1,500 cobia fingerlings supplied by the CMFRI, Mandapam with average length and weight of 16.5 cm and 44 grams respectively were stocked in two GI cages. The average weight of harvested fish was 2.5 kg. They were sold at farm gate price of ₹350/kg and a gross revenue of ₹2,61,100 was realised. The total operational expenditure was ₹1,76,000 and the income over operating cost was ₹85,100. The operating (cost: benefit) ratio was 0.67, which implies there is 33 per cent profit due to the farming.

Continued Adoption of CMFRI Technology–Sea Cage Farming of Cobia by the fishermen SHG of Munaikadu, Ramanathapuram District, Tamil Nadu

Owing to the profit and understanding the potential in sea cage farming of cobia, they continued the adoption of the farming with their own investment during 2016. Hatchery produced 1,500 numbers of cobia fingerlings were supplied by the ICAR-CMFRI, Mandapam with an average length and weight of 16.5 cm and 39 grams respectively, were stocked in two GI cages of 6 meter dia and 3.5 meter depth during first week of May 2016. The ICAR-CMFRI, Mandapam has provided necessary technical guidance and support. After 195 days of culture period, on 24th November 2016, a total of 2,180 kg of cobia fishes were harvested. The average weight of harvested fish was 2.2 kg. They were sold at farm gate price of ₹225 / kg and a gross revenue

a. Cobia fingerlings
b. Cobia in sea cage

of ₹4,90,500 was realised. The total operational expenditure was ₹2,60,000 and the income over operating cost was ₹2,30,500.

Training Programme–Marine Sea Cage Farming" under FIMSUL-II project organised at Mandapam Regional Centre of ICAR- CMFRI

Training Programme on "Marine Sea Cage Farming" was conducted to the fishers and fisheries officials under FIMSUL-II project of State Fisheries Department, Tamil Nadu at the Regional Centre of ICAR-CMFRI, Mandapam in three batches. 56 fishers and 5 fisheries officials from Kanyakumari, Pudukottai, Ramanathapuram, Kancheepuram and Pudukottai district attended the training program.

Tuticorin

Lobsters culture in small Iron frame net-cages with different stocking densities

Juvenile lobsters (*Panulirus homarus*) with individual weight ranged from 40 to 60g were stocked in four Iron frame net-cages (2 m x 1.5 m x 1.5 m). The stocking densities maintained were 83 nos per m^2. The average final weight of the grown lobsters were 226.86 g, with an Average Daily Growth (ADG) of 1.08 g. The survival of 90 % as observed at the time of harvest. The farm gate price for lobsters grade-I were ₹2250 and ₹1700 per kg for grade-II.A revenue of ₹1, 75,972 was achieved in a culture period of 130 days from four Iron frame net-cages by the two fisher groups.

Farmers innovation in lobsters culture : Iron frame net-cages

Baby lobsters (*Panulirus homarus*) with average weight of 70g were stocked in two Iron frame net-cages (4 m x 2.5 m x 1.5 m). The stocking densities maintained were 65nos per m^2. The lobsters were fed ad libitum with trimmed cuttlefish waste and clam meat twice daily. An harvest of 72 kg lobsters with 38 kg of grade-I was obtained. The average final weight of the grown lobsters were 204.3 g. A sale of ₹91, 780 was achieved in a culture period of 130 days from one Iron frame net-cages by the two fisher groups under the scientific farming practices and guidance of ICAR-Tuticorin Research Centre of CMFRI.

Lobster culture in GI sea cage

Lobsters juvenile with an average weight of 60 g are stocked in 7M dia GI sea cage. The stocking densities maintained at present is 80 nos per m^2. The lobsters were fed ad libitum with trimmed cuttlefish waste and clam meat twice daily. The lobsters cage is being maintained by two fisher groups under the guidance and scientific farming practice of ICAR-Tuticorin Research Centre of CMFRI

Bivalve farming

Mussel farming

Large scale on bottom farming of green mussel, *Perna viridis* was taken up by the farmers in Thekumbhagam, Dalavapuram, Kallada, Vellimon, Koyivala, Aravila, Pampa, Kureepuzha, Prakulam, Pallapu, Kadavoor, Sampranikudi, St. Thomas island and St. George Island and Fathima Island of Kollam District. The seeds were collected from Calicut, Kannur and Thalaserry at the rate ranging from ₹2700 to 3000 per 70Kg seed. These seeds of size range 2.5 to 3cm were used for on bottom culture.

Integrated multi-trophic aquaculture (IMTA) of mussel and finfish was initiated in estuarine areas of Sumana Estuary of Karnataka. The green mussel was farmed as the organic extractive component in IMTA by rack & rope method near fish cages. The cages were stocked with wild-caught fingerlings of red snapper during the preceding pre-monsoon season. 200

culture ropes were farmed in the IMTA system, by suspending them from the bamboo racks. The farm grown mussels were harvested in June 2016 and marketed at a farm gate value of Rs.3/shell-on mussel along with the farmed finfish. By exploiting the extractive capacities of co-cultured lower trophic level taxa, the IMTA farm obtained added products and thereby increaing the profits through diversification.

Unprecedented heavy spatfall of mussels of the green mussel was observed in intertidal and sub-tidal mussel beds along Goa, Karnataka and Kerala Coast during September to December 2016. In Malabar area from Padanna to Kadalundi in the ten major estuaries, 377.5 tons of mussel seeds/mussels were taken with a cpue of 72.85 Kg. Mussel spat settlement was also observed on oyster shells and on sandy substratum near bar mouths and estuaries along the Karnataka Coast. In Karnataka nearly 53 mussel farms operated in Udupi District due to seed availability.

Mortalities in farmed mussels were observed by March 2016 at Padanna, Kasargod, Kerala. 60–80% mortalities were observed in some of the farms. Samples of apparently healthy, gaping, moribund and dead *P. viridis* were collected for analysis. RFTM culture showed 70-80% infection with *Perkinsus olseni*.

Oyster farming

Twenty tons of farmed edible oyster, *Crassostrea madrasensis* was harvested at Moothakunnam and Puthenvelikkara (Ernakulam District) in June 2016. About 10 farms with 350-400 strings each were harvested. These were jet washed, depurated at the Moothakunnam Value Added Production (VAP) unit. The oyster meat were sold through the ATIC of CMFRI, Kochi at the

a. Oyster harvest in progress at Moothakunnam.
b. Oysters being processed at the VAP unit

rate of ₹600/kg. 35 kg of depurated steamed oyster meat was sent to “Shangi Food” Mumbai at the rate of ₹1000/- per kg under the brand name “Muziris oysters”

Technical guidance was provided for horizontal spread of bivalve farming activities along the coast of Karnataka. Farmers from the Sita Swarna Estuary, Udupi District were trained in various aspects of oyster farming techniques. 40 racks were completed for oyster farming. Seventy eight farmers ventured into oyster farming by rack and ren method in Udupi District for the first time. The number of ren per rack varied between 120 and 200.

The Nine bivalve fishers, mostly women started oyster farming by setting spat collectors during the post-monsoon season. The Department of Fisheries, Government of Karnataka, provided financial assistance of ₹40,000/- under the Rashtriya Krishi Vikas Yojana (RKVY) Programme. The oyster farms were fabricated by the farmers in shallow estuarine waters of (Kolachikambala) Sambhavi River and (Padubailu, Karnad) Pavanje River. The oyster harvest was carried out in batches and the shucked meat was supplied to local markets, restaurants, bars, households and as well marketed through the outlets of Karnataka Fisheries Development Corporation, Mangalore.

In situ green mussel feeding experiments at Padanna Backwaters

Green mussel carrying capacity of padanna estuary.

Standardisation of protocol for the in situ estimation of the filtration rates for the estimation of carrying capacity of bivalve farming areas was carried out at Padanna, Kerala. With rapid growth in mussel farming, the farmers sourced seeds from distant locations resulting in poor seed quality at the time of seeding. This resulted in tended mussel farmed stocks which were susceptible to stress. Furthermore, the environmental degradation in the farmed area of Padanna due to excessive number of farms per unit area and reduced flushing of waste in certain pockets (Edayilakkadu bund) was burdened by the extremely high ambient air and water temperatures in 2015-16. This resulted in a crisis in February 2016, leading to stunted growth, high mortality and prevalence of the protozoan parasite, *Perkinsus olseni*.

The Institute has been monitoring the mussel farming activity in the area, identified the issues and suggest solutions to farmers and the Government. The adoption of sustainable aquaculture practices in Padanna Backwaters by improving the quality of seeds, enhancing the flushing rates, modifying the farm layout and reducing the farming density per unit area were among the 21 recommendations proposed in the detailed report which was submitted by the Institute to the Govt. of Kerala.

Training on bivalve farming was organised at Mulki on 21-22 July 2016 on mussel seeding, fabrication and hygienic shucking of oyster meat for 32 participants.

Demonstration of mussel farming for 65 fishers was conducted at Payyanur Nagarashabha hall on 9.12.2017 as part of the 'Matsya Samrudhi Programme II' of the Fisheries Dept, Govt of Kerala. The fishers were given training on the seeding techniques and rack fabrication.

Training was organised on 23 Dec 2016 at Udupi for 47 participants on mussel seeding and oyster ren fabrication.

Training on bivalve farming at Mulki, Karnataka

All India network project on mariculture

Research Project: EFP-37

All India Network project on mariculture was initiated to have a focused research in mariculture and transfer the marculture technologies to farmers through networking of various centres situated along the coasts of India. CMFRI along with 6 collaborating centres from state agricultural universities of Gujarat, Maharashtra, Karnataka, Andhra pradesh, Odisha and West Bengal is operating AINP Mariculture. Under AINP, five major programmes viz., GIS based site selection, technology demonstration, broodstock development and seed production, mapping of natural seed resources and live feed culture were undertaken during 2016-17. 48 potential

sites were identified for cage culture along Indian coast through GIS based site selection. Participatory programmes in cage farming were carried out in association with State Fisheries Departments and identified Self Help Groups at various locations by the particiapting centres of the AINP-M. Survey of natural seed resources in both west and west coasts carried out for finfish species prioritised for mariculture. Successful Breeding of Grouper and carangids was the major achievements under AINP -Mariculture. Marine copepods mainly calanoids and cylopoids were isolated and identified from Vizhinjam and Karwar waters and being cultured in mass scale as live feed in respective centres.

Gujarat

Technology Demonstration programmes of cage farming was undertaken by Veraval Regional Centre along the Kutch coast with the involvements of selected fishermen groups. Lobsters were stocked in two square GI cages @1000 numbers per 6 m x 6 m cages and were fed with chopped trash fish at a rate of 10% of their body weight. The survival rate and the average growth rate of the lobsters were 88.94 % and 1.12g/day respectively. Crab fattening trials were carried out in Mangroove pens for a period of 90 days and recorded growth rate of 4 g /day.

Maharashtra

Development of brood stock of silver pomfret (*Pampus argenteus*, Euphrasen, 1788) and rabbit fish (*Siganus vermiculatus*, Valenciennes, 1835) was initiated at Marine Biological Station, Ratnagiri. A survey was carried out for mapping of natural seed resources in Maharashtra

Crab fattening in mangrove pens

and recorded *Siganus vermiculatus* as the most dominant species.

Karnataka

Karwar Research Centre of CMFRI undertaken cage technology demonstration programmes, GIS based site selection, mapping of natural seed resources and live feed culture as the major activities.

Broodstock development of rabbit fish

Site survey: Preliminarily study was conducted to find out potential sites for cage farming based on topography, water quality, acceptability, socio economic suitability in the state of Goa. Based on this survey, 6 potential sites were selected subsequently, feasibility survey was conducted in North Karnataka region also. In this area 3 potential sites were selected.

Technology Demonstration: Under technology demonstration programme, identification of Self Help Groups from four different areas of Karnataka and Goa was initiated. Four areas were selected viz., Majali, Kadwad, Honnavar and Kumta for identification of suitable sites as well as the formation of Self Help Groups. Made preliminary survey in the selected areas and found suitable for cage culture at Majali and Kadwad.

Identification of Self Help Groups: Karwar Research Centre of CMFRI initiated formation of Self Help Groups of coastal communities in Uttara Kannada district of Karwar for expanding the mariculture activities and also to improve the economic status of fishermen community. Self help groups were formed in different areas viz., Kumta, Honnavar, Ankola, Majali and Kadwad. The criteria selected for the selection of the group are mainly based on the socio-economic status of individual family. They were exposed to various awareness programmes in order to provide them with the necessary knowledge, skills, motivation and competence. Hence, the training programmes organised for the SHG members were of great significance in the poverty alleviation programme pursued through Self-Help Groups. The self help groups were also selected according to the suitability of that particular area for the mariculture activities. Out of these five places from uttara kannnada, five men and two women groups were identified from Kumta. In Honnavar, two men and two women groups were identified. From Ankola, Majali and Kadwad, one men and one women group from each location was identified. Self help groups will be given training on marine and brackishwater cage culture, Integrated Multitrophic Aquaculture, Nursery rearing. Given the support, together with appropriate knowledge and skill inputs with better utilisation of manpower and capital implementation of cage culture technology forms as an additional income generation option for the coastal communities and to elevate their socio-economic status.

Organised training programme for Research scholars and technical staff from various centres involved in AINP-Mariculture activities. All the participants were given awareness about the AINP objectives and specific targets of the AINP Mariculture and also given hands on training on various aspects of cage farming in marine and brackishwaters. A total of one hundred and twenty fishermen and officials from Mumbai and Karwar were given hands on training on Cage culture technology during the period 2016-17.

Natural seed resources: A survey on the natural seed resource availability of marine finfish was made in eight villages near Karwar and five villages at Goa. Basic data was also collected

Identification of Fishermen Self Help Groups along Karnataka coast

from fishermen of the selected villages. Fish seed were collected using cast net and drag net in all the selected areas at weekly intervals. Out of 24 species prioritised for mariculture, eight 8 were recorded along Kali estuary. C.ignobilis was found to be the most dominant species of Kali estuary in premonsoon and monsoon seasons, whereas, Mugil cephalus was the most dominant species during post monsoon season. A significant variation was recorded in the occurrence, abundance of seed between areas and between seasons. A survey was also carried out in two marine waters areas of Karwar and found carangids, mullets and Sillago

Awareness and training programmes to fishermen SHGs on cage culture technology

spp. as most dominant species. Seed survey along the coast of Goa was carried out in three marine (Talpona, Polem and Galgibagh) and two estuarine (Zuari and Mandovi) areas. Snappers, Pomfrets and mullets are the most dominant seed resources of marine waters. In estuarine waters, snappers, mullets, carangids and Sillago sihama are the most dominant. *Lutjanus argentimaculatus* and *L.j ohnii P. chinensis* were the most dominant species in Talpona. Caranx spp. was the most dominant in Polem and Galgibagh.

Live feeds: A new cyclopoid copepod, *Apocyclops cmfri* sp. nov was identified from Karwar waters through morphological and molecular taxonomy and deposited to CMFRI repository (CMFRI Accession No: EF.6.7.2.1) and NICBI (GenBank Accession no. KX263726). Experiments were carried out to study life cycle of the species. The shortest life cycle (8 days) of cultured *Apocyclops* copepod was recorded when fed with *Chaetoceros*, whereas the life cycle was lengthy (15 days) when fed with *Chlorella*. The study revealed that maximum number of eggs were produced by *Chaetoceros* fed copepods, with 90% hatching rate and with a survival rate of 95%. It was observed that *Chaetoceros* is the best algal diet for high fecundity and survival of cyclopoid copepod isolated from Karwar waters. Mass production protocols of *Apocyclops cmfri* sp. nov. were standardised with a maximum naupliar production of 10 million per tonne.

Brood stock development of Sand Whiting (*Sillago Spp.*) and Milk Fish (*Chanos chanos*) was initiated by Fisheries Research and Information Centre (Marine), Ankola, Karnataka. Participatory cage culture demonstrations initiated by the conduct of training programmes to the fishermen of Karnataka. A total of 22 fish seed resource survey were conducted along the coast of Uttara Kannada District. The survey revealed rich resources of sand whiting, mullets and pompano in addition to new potential resources like barracuda and Indian salmon.

Broodstock development of milk fish at Ankola Research Station

Kerala

Cage culture technology demonstration was undertaken in Ernakulam, Thrissur and Kottayam districts and stocked with seabass and Etroplus. Integraded Multitrophic Aquaculture in Engandiyoor was initiated and the cages were stocked with red snappers, sea bass, GIFT Tilapia, Red Tilapia and Etroplus along with 1100 ropes of 1 m seeded mussels.

Farmers from North Paravur were given hands on training to fabricate GI Square (4x4 m) and circular cages (6 m dia) and launched in the brackish water areas. Thousand numbers of carangid seeds (50 to 60 mm) were collected from nearby locations and reared in the happas

Successful harvest of pearl spot at Kochi

inside the cage. The juveniles were fed with pellet feed and trash fishes @ 10% of their body weight. Fishes attained a size of 1 to 1.5 kg after 10 months of culture and the survival was 80%.

Cage culture technology demonstration was undertaken by Vizhinjam Research Centre at Kochuthuruth area and Chemmakkad area with the installation of four GI floating cages of 4x4m size. Two cages were stocked with sea bass fry of 10g size. In other cages, seeds of spiny cheek grouper, Epinephelus diacanthus collected from Paravoor area were stocked with an initial size of 55g. average size attained by seabass was 300 g in five months of culture, whereas, grouper reached a size of 100 g within two months of culture. Culture is under progress. Successful breeding of carangids was made at Vizhinjam Research Centre.

Mariculture facilities were developed at Narakkal Campus of CMFRI. The centre Initiated breeding programs of marine finfishes and the mass culture of Copepods Oithona similis and O. Rigida.

Seed survey trials conducted throughout the coast from Varkala to Kollam revealed rich resources of snappers, groupers, carangids and sillaginid fishes. quantification of the seed availability is progressing. Seeds of spiny cheek grouper, Epinephelus diacanthus were collected and

a. Integrated farming of fish and mussel
b. Cage reared *Caranx ignobilis*

reared. Survey was conducted along Kollam Coast revealed that cage culture can be initiated in certain areas near Thankaseery, Thirumullavaram, Ozhukkuthode and Astamudi. Two sites were selected for cage farming Kochuthuruth and Chemmakkad areas of Astamudi. Three groups were identified for farming. Survey from Kollam to Ponnani and found seed availability was more concentrated in Kollam, Alleppey, Cochin, Munambam, Chettuva and Ponnani where bar mouth and associated estuarine areas are more prevalent. Smaller seeds are available with areas nearer to the sea and bigger seeds are available in low saline creeks or rivers.

East coast: Technology demonstration programmes of cage culture along east coast were carried out at Tamil Nadu, Andhra Pradesh, Orissa and West Bengal. Asian seabass, cobia, pompano, groupers, mullets and milk fish are the major species cultured in cages along east coast.

Cage culture technology demonstration at Chemmakkad

Mariculture facilities at Narakkal, CMFRI

Tamil Nadu

Trial farming of blue swimmer crab, *Portunus pelagicus* was initiated by Mandapam Regional Centre at Vedalai village, Ramanathapuram district in a participatory mode with a fishermen group. A pen with a dimension of 10×10 ft made of fish net, was fabricated and installed using casuarina poles. A total of 3000 nos. of crablets produced in the hatchery facility of the Mandapam Regional Centre of CMFRI, measuring an average carapace width of 5mm were introduced in the pen. The pen and crablets were provided by the CMFRI. Feeding, daily maintenance, watch and ward were carried out by the fishermen group. Culture is under progress.

Brood stock development and seed production: Sub adults of *Lutjanus rivulatus* and *Lethrinus nebulosus* were collected from trap net operators, transported to MRC and after quarantine period released to the cages for brood stock development. High density larviculture of cobia was done in 2 t capacity flow through systems at Mandapam and achieved a better survival of 6%.

Standardisation of seed production of blue swimmer crab *Portunus pelagicus* : A Total of 174 ovigerous females with deep grey color egg mass were used for spawning trials. The hatching rate obtained during the period was ranged between 43.5% to 95.3% respectively. Larviculture of hatched zoea was carried out by adopting green water technique supplemented with zooplanktons of appropriate quality and quantity. An average survival of 5-7% achieved from Zoea stage to 1 inch crablet size. The duration of each of the first three zoeal stages was 3-4 days, the following stage4-6 days, and the megalopa 5-7 days, reaching the first crab stage in 18-25 days.

Seed Survey carried out in 8 villages along the Palk Bay and recorded *Siganus* sp, Mullets, Snappers (*Lutjanus* sp) Breams (*Lethrinus*),Goat fish (*Upenaeus* sp), Pony fish as the major dominant species.

Andhra Pradesh

Cage farming demonstration of seabass and silver pompano was demonstrated in back waters of Krishna river at Nagayalanka, Krishna District by Visakhapatnam Regional Centre. A total of 13 cages were used, of which 11 were wooden cages (square shaped; 4 x 4 x 2 m size) and 2 were HDPE cages (circular with 6 m dia). The cages were installed with help of barrels for floatation and anchor (iron and stones) for mooring. All the cages were stocked with 6 inch sized sea bass and were fed with trash fishes. Total of 500 numbers of fish seeds were stocked in each cage. Fishes has grown to 0.5 kg to 1 kg in 5-8 months of culture period. A total of 3 ton of sea bass was harvested from cages and sold in live at the rate of ₹340 per kg.

Broodstock development and breeding of Indian pompano (*Trachinotus mookalee*): 17 adult fishes of Indian pompano (3.0- 5.0 kg) were stocked in re-circulatory system for broodstock development. The fishes were fed twice a day with clam and squids till satiation.

a. Cage culture harvest of marine fin fishes at Nagayalanka
b. Implantation of LhRH to Indian pompano adult

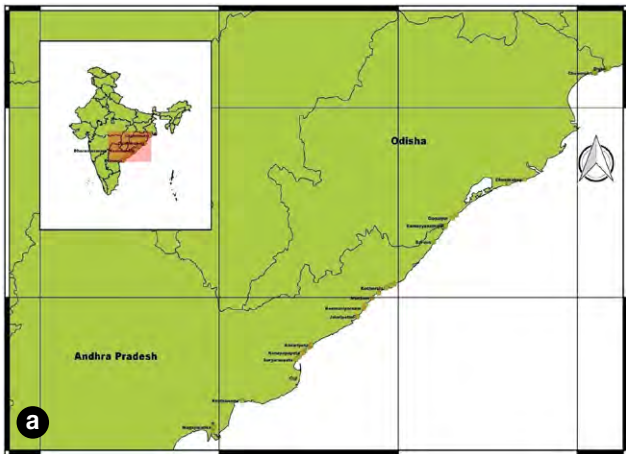
The feed was fortified with vitamins (E, B, C and A) and mineral mixture regularly in order to supplement any possible nutritional deficiencies in their diets. The gonad development of fish was assessed monthly by cannulation. In addition, twenty more adult fishes are stocked in cage for broodstock development of Indian pompano. Fishes were implanted with Luteinizing hormone-releasing hormone (LhRH) @ 60 µg per kg body weight for inducing the maturation of the fish after every two months interval. Six adult fish were found to be female and 7 adult fishes found to be male out of total 17 fishes. Two matured female with ova diameter of more than 500 µm and oozing male were selected and induced with single dose of hCG on 10 February 2017. The fishes responded after 36-40 h of induction, however the fertilisation rate was very less, so the eggs were not collected for larval rearing.

Giant trevally (*Caranx ignobilis*) broodstock development: *Caranx ignobilis* were collected for broodstock development and maintained in cages with a size ranged between 2.0 to 4.5 kg. The fishes were fed twice a day with sardine and other trash fish fortified with vitamins and mineral mixture regularly. The gonad development of fish was assessed monthly by cannulation.

GIS based site selection for cage culture: A preliminary survey was conducted to find out the suitable place for cage culture operation in Andhra Pradesh, Odisha and West Bengal states. In the first phase of survey, a total of 34 sites were examined from 5 districts in Andhra Pradesh, 3 districts in Odisha and one district from west Benagl among which 28 different locations were selected based on the suitability of parameters for culture of fishes in cages.

Seed survey of prioritised species: seed survey was conducted along the coast of Andhra Pradesh (4 district; 12 places) and Orissa (2 district; 2 places). The most dominant group found was mullets, followed by Chanos, sillago, Snapper, Siganus, Etroplus and seabass. The influence of lunar periodicity on finfish seed abundance is evident from the number of fish seed in seed haul per net per day. Mullets were more abundant in the last quarter, whereas

a. Site selected for cage culture activities
b. Seed survey sites along Andhra Pradesh and Odisha Coast



Sillago sp. was more frequently encountered during new moon. Availability of milk fish was very less during last quarter and full moon and it was absent during first quarter and new moon.

Technology demonstration of cage culture was undertaken at Suryalanka by Fisheries Research Station, Kakinada, installed 3 cages with different diameters of 4m, 6m and 8m and stocked with mullets, seabass and milk fish respectively. Culture is under progress.

Odisha

Cage farming of Tilapia and pearl spot was initiated by College of Fisheries, Orissa University of Agriculture & Technology, Berhampur. Experimental trials made on stocking density and production of fish in three cages and recorded maximum production of 9.2 and 6.7 kg /m^3 against 5.0 kg/m^3 in Pond based practices (60% yield enhancement). Seed Resources survey along Ganjam, Sonepur, Gopalapur of Orissa coast was carried out and found mullets, seabass, Etroplus are the most dominant fish seed.

West Bengal

Cage culture demonstration: Two circular cages (4.5 m dia.) were fabricated and installed by West Bengal University of Animal & Fishery Sciences (WBUAFS) in Digha coast. Awareness programmes on cage culture were carried out at eleven different places along Orissa coast. Infrastructure facilities viz., eight (8) rectangular and two (2) circular tanks with shed have been developed after thorough repair and renovation with help of Dept. of Fisheries, Govt. of West Bengal at Digha, in which fish seeds are rearing. A survey carried out on the availability of fish seed and recorded mullets and seabass as the most dominated species.

A total of 30 demonstrations and 75 trainings all over India were undertaken under AINP-Mariculture. Identified 48 potential sites for cage culture along Indian coast. Survey of natural seed resources in both west and west coasts carried out for one year and identified mullets, milk fish and snappers are the major dominant prioritised species for capture based aquaculture. Recirculatory Aquaculture systems brood stock maintenance with 100 tonne capacity was developed at Karwar and other centres viz. Mandapam, Visakhapatnam and Vizhinjam. Marine copepods mainly calanoids and cylopoids were isolated, identified from Vizhinjam and Karwar waters and being cultured in mass scale as live feed. Brood stock of snappers, cobia, groupers, carangids and Pompano was maintained in RAS systems. Successful Breeding of carangids was the major achievement under AINP -Mariculture.

Cage installation at Digha

Muzhappilangad Mangroves: Regulating and Supporting services

Marine biodiversity

Bioinventorying and Biodiversity Valuation of Marine Organisms in Selected Marine Ecosystems along the Indian Coast

Research Project: FISHCMFRISIL201201500015

Biodiversity valuation of ecosystems of Kerala

The value of ecosystem services was estimated for nine districts of Kerala using the standard methodologies. Provisional services like fisheries, aquaculture and agriculture together forms about ₹1300440 /ha /yr. ($ 28899 /ha /yr). The value estimated for the regulating services like

water regulation, shoreline protection, gas regulation and carbon sequestration was ₹22879796 /ha /yr ($ 508440 /ha /yr); value for supporting service, nutrient cycling was ₹17890 /ha /yr ($ 398 / ha /yr) and the estimated value for cultural services like tourism was ₹11763480 /ha /yr ($ 261410 /ha /yr). The valuation shows that the Kerala state has high values for ecosystems due to several reasons such as the presence of vast wetland ecosystems, rich biodiversity, age old practices of prawn- rice culture, formation of mud banks, upwelling, agriculture along the coastal areas and two monsoon seasons.

Biodiversity of Gulf of Mannar Ecosystem

The diversity of echinoderm fauna from Gulf of Mannar, Palk Bay was 23% of the specimens from Asteroidea, 24% Echinoidea, 22% Ophiuroidea, 3% Crinoidea and 28% Holothuroidea. The new record of Apogonid fish *Pseudamia gelatinosa* Smith, 1956 was recorded in the Gulf of Mannar waters. The review of the apogonids diversity revealed that there are 69 species present in Indian waters including the island territories from 18 genera and the *Ostorhinchus* genus being the most speciose among them. Steps have been taken to include *Apogonandhrae,* an apogonid species described from Visakhapatanam waters to be included in the global database.

Jellyfish swarming occurred during the summer months along Palk Bay and three species were recorded *viz., Mastigias papua, Netrostoma coerulescens, Chrysaora* sp., in the shore seine operations along Panikulam coast. Christmas tree worm observed in the coral reef ecosystem of Palk Bay were found to belong to the *Spirobranchus corniculatus* complex. Four species of corals,*viz*., *Montiporama nauliensis* Pillai, 1967, *Porites minicoiensis* Pillai, 1967, *P. mannarensis* Pillai, 1967, *P. exserta* Pillai, 1967 described in 1967, have been now included in the global list, thus enhancing the global diversity of corals under these genera. Indigenous technical knowledge on the sea urchin roe cuisine has been documented from the fisher folks of Manangudi village.

Valuation of Karnataka Coastal Ecosystem

The coastal zone in Karnataka is having a coastline of 320 km from Ullal in south to Majali in the north with 27,000 sq.km of continental shelf and 87,000 sq. km of Exclusive Economic Zone. The State has 5.2 lakh hectares of inland water resources comprising of 2.93 lakh hectares of major and minor tanks, 2.67 lakh hectares of reservoirs and 5813 kms length of rivers. Karnataka coastal region has 13 main rivers that drain into it – Nethravati, Gurupur, Udiyavara,

Cultural and Supporting services at Tagore beach in Karnataka

Mulki and Pavange, Sita and Swarna, Haladi, Chakra, Kollur and Baindur, Kalinadi, Gangavali, Aghanashini, Sharavathi and Venktapur. There are 26 estuaries with more than 70,000 ha of water-spread area and 8000 ha of brackish water area, making the three coastal districts of Karnataka very rich in marine, estuarine and riverine biodiversity.

Provisioning Services include food, water and other resources obtained from the ecosystem. Coastal ecosystems are one of the most productive ecosystems in the world which is particularly productive and diverse. Algal beds, sea grass meadows, reefs, estuaries and mangroves provide food and shelter for vast quantities of fish, shellfish, and other marine organisms. The major provisional service which is seen in the coastal waters is the marine fish production. Karnataka has 110 fish landing centres including five major fishing harbours with a total landing of 4.74 lakh tonnes having an approximate value of ₹4461 Crores. This includes the value of finfish catch which is 74.4% of the total value of landings while, crustaceans contribute to 13.7% followed by cephalopods contributing 12.17%.

Investigations on vulnerable coral reef ecosystem of Indian waters with special emphasis on formulation of management measures for conservation

Research Project: FISHCMFRISIL201201500016

Hard Coral Diversity

Coral diversity, fish assemblage, and other bio-resources associated with coral reefs of Grande island, Gulf of Kutch, Goa, Palk Bay, Tuticorin Major Harbour and Androth, Kalpeni and Bitra Islands of Lakshadweep were investigated following the Line Intercept Transect (LIT) and Underwater Visual Census (UWVS) methods.

Hard Coral diversity of Bitra Island.

Bitra Island

Bitra is the northern most, smallest inhabited island area (0.105 km^2) with the third largest lagoon area (45.61 km^2) in Lakshadweep. It has a length of 0.57 km and a width of 0.28 km at the broadest point. The island is located at N 11.598° and E 72.187°. The diversity and distribution of corals was more in the reef knolls than in the shallow areas of lagoons. The reef knolls consist of sub-massive/massive coral forms, whereas branching and solitary corals forms were also observed. The areas around South Bay were mostly sand with rubbles and dead corals.

73 species of Scleractinia (32 genera & 13 families) were recorded in the present study. The most diverse family as per numbers of species is that of Merulinidae (19 species) followed by Acroporidae, Fungidae and Poritidae. Bleaching was noticed in few *Porites* and *Acropora* genera only. Algal cover was less in the observed transect area of the present study. New recruit of Acroporids was also observed in the knolls.

Androth Island

Androth is the largest Island in the Lakshadweep group with an area of 4.83 km^2. In general, the diversity and distribution of corals was more in the reef flats all around island and in the shallow areas with the exception in north eastern side. The depth of the north eastern part of the surveyed area ranged from 2 to 8 meters and the western side 0.5 to 2.0 meters during the low tide. The intertidal areas around the 'Moola' have many new recruits of different corals; few of the massive and sub-massive corals were exposed during the low tide. 71 species including two non-scleractinian corals genera *Heliopora coerulea* and *Millepora platyphyllia* belonging to 32 genera and 13 families were recorded. In terms of species diversity, the genus *Acropora* (16 species) and *Porites* (5 species) dominated followed by 4 species each of Platygyra, Favites and Pocillopora. Other genera are represented by less than three species.

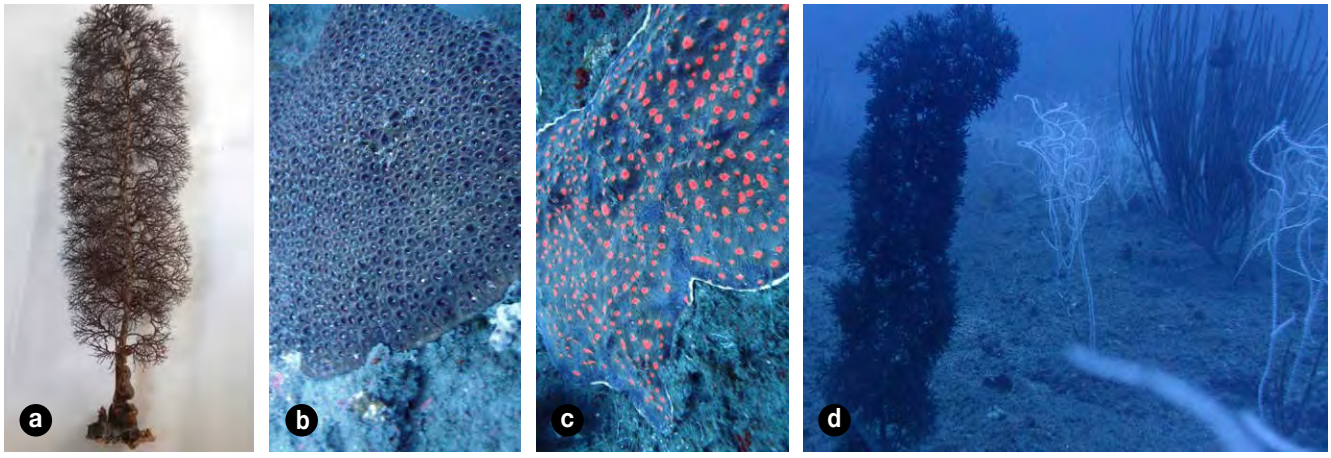
Kalpeni Island

Kalpeni is a complex of two major islands viz., Kalpeni and Cheriyam along with several small islets. This Island has a very large lagoon with the depth ranging from 1 to 5 meters. There are two small islands (Cheriyam and Tilakkan) which are uninhabited and situated in the south-western part of the lagoon. On the windward side, the beaches are sandy while on the leeward side, the beaches are made up of coral boulders and coral shingles. 69 species of reef building corals (26 genera and 13 families) including two non-scleractinian corals genera *Heliopora* sp. and *Millepora* sp. were recorded.

Off Puducherry

The offshore hard bottom of Mesophotic Coral Ecosystem (MCEs) situated off Pondicherry on the east coast of India was surveyed through under water diving (SCUBA) to document the biodiversity. The wall was 2.5 km long and 0.05 Km wide and covers an area of ~ 12.5 hectares (0.125 km^2). The width of wall was ~7 m. SCUBA diving was carried out during February to March, 2017 from 10 stations off Pondicherry in the east coast of India. The specimens were collected using SCUBA at a depth-range of 33–37 m.

12 species of hard corals belonging to 7 families were recorded. *Leptoseris hawaiiensis, Pavona minuta, P. maldiviensis* (Agariciidae), *Tubastraea micranthus, T. coccinea* (Dendrophylliidae), *Euphyllia ancora* (Euphylliidae), *Cycloseris* sp. (Fungiidae), *Hydnophora rigida, Goniastrea pectinata, Dipsastraea favus* (Merulinidae), *Psammocora haimiana* (Psammocoridae), *Pachyseris speciosa* (*Scleractinia incertae sedis*). 6 species of black corals belonging to Antipathidae were recorded (*Cirripathas spiralis, Pseudocirrhipathes mapia, Stichopathas luetkeni, Antipathes dendrochristos, A. grandis, Cupressopathes abies*) and 5 species of gorgonids belonging to 7 families were recorded. *Leptogorgia* sp., *Eugorgia* sp., (Gorgoniidae), *Ellisella* sp.(3 species), *Dichotella gemmacea, Junceella* sp. (Ellisellidae), *Alackagorgia* sp., *Muricella* sp., *Acanthogorgia*



a. *Antipathes* sp
b. *Dipsastraea favus*
c. *Montipora* sp
d. *Cupressopathes abies*
e. Gorgonid forest with school of fish

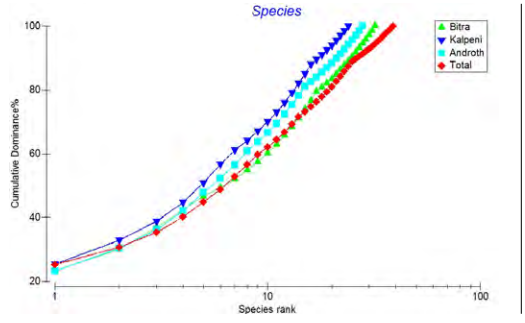
sp., (Acanthogorgiidae), *Subergorgia* sp. (Subergorgiidae), *Menella* sp., *Echinogorgia* sp. (Plexauridae), *Acabaria* sp., (Melithaeidae)'

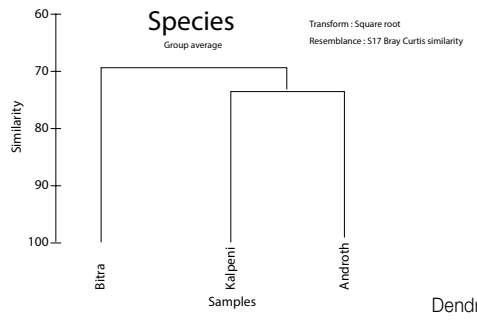
Biodiversity Analysis

A community diversity analysis to discern the species status for Bitra, Kalpeni and Androth Islands, Lakshadweep was derived in the Table.

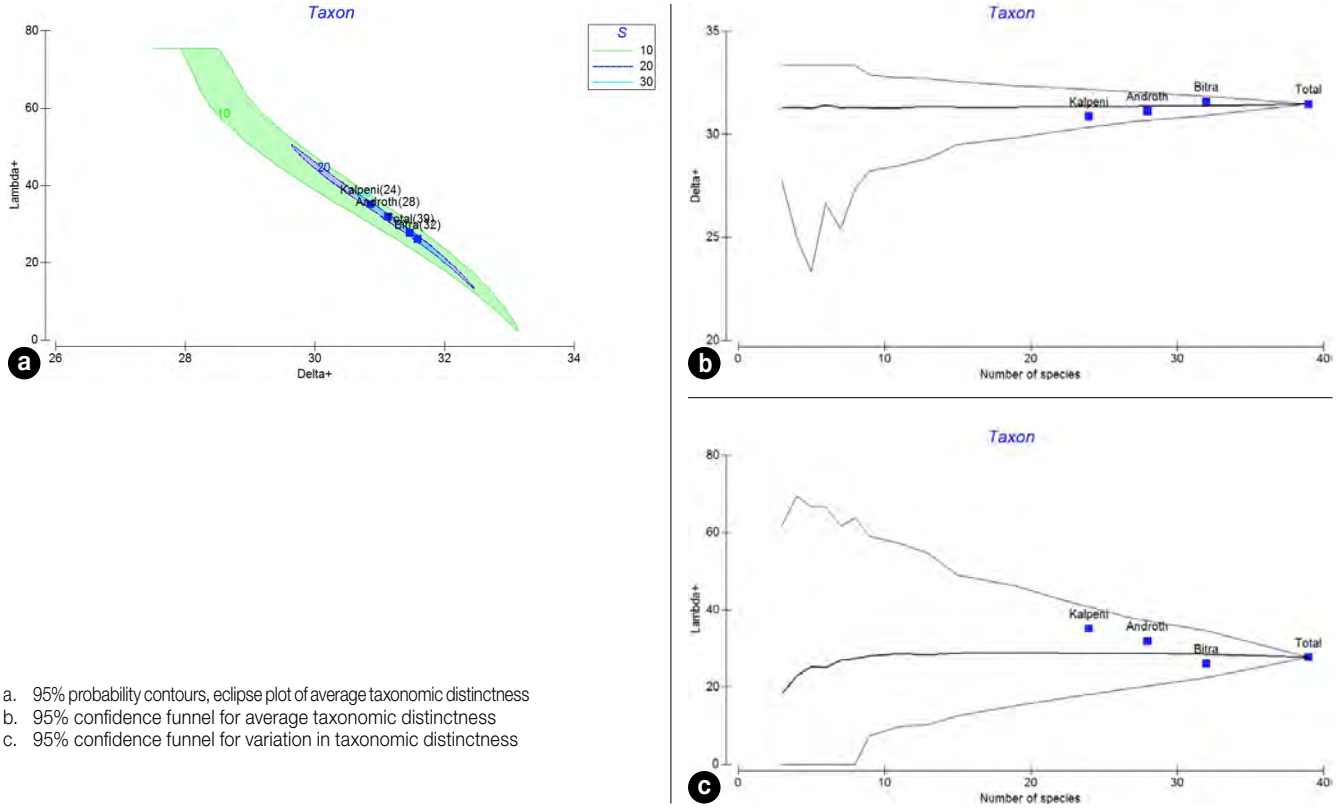
Diversity indices for scleractinian corals in the Bitra, Kalpeni and Androth Islands, Lakshadweep

	Delta	Delta*	Delta+	sDelta+	Lambda+	Phi+	sPhi+
Bitra	30.10	32.27	31.59	1010.75	26.07	25.52	816.67
Kalpeni	29.25	31.87	30.86	740.58	35.13	27.08	650.00
Androth	29.39	31.60	31.13	871.60	31.88	26.19	733.33
Total	29.37	31.85	31.47	1227.19	27.63	24.36	950.00





Dendrogram of Scleractinian corals



a. 95% probability contours, eclipse plot of average taxonomic distinctness
b. 95% confidence funnel for average taxonomic distinctness
c. 95% confidence funnel for variation in taxonomic distinctness

The dominance plot was constructed on the data sets to find out the biodiversity pattern and the curve for the three Islands which lies on the lower side, extends further and rises slowly due to presence of more number of species.

Palk Bay

Coral bleaching was observed in massive forms than the branching forms during this survey and the bleaching susceptibility due to "shall top" is more prominent in Palk Bay corals. Taxonomic status of the reported coral diversity was assessed during this period and the Scleractinian Coral Diversity stands at 128 species from 16 families in Gulf of Mannar and Palk Bay put together. The families Acroporidae, Merulinidae and Poritidae occupy the first three positions in terms of diversity.

Grande Island, Goa

Among the three stations surveyed in the patch reefs of Grande Island, Lobster Avenue site had a total coral cover of 45.9% of the surveyed transect area followed by sponges (6.6%) and dead corals having encrusting algae (4.6%). In the Chow Point site the estimated coral cover along the transect was 40.23%, followed by sponges (8.78%) and green algae (3.68%). The Jetty site had comparatively less coral cover of 20.12% and the sponge cover was 2 % of the total transects area.

Bacterial diversity

Samples of corals (normal, bleached and diseased), soft corals, sponges, seawater as well as sediment were collected from all the sampling stations for detailed bacteriological analyses. Predominant bacterial colonies of culturable bacteria grown on general as well as selective media were purified and a total of 284 (208 from Kalpeni and 76 from Androth) pure

bacterial isolates obtained were characterised by detailed morphological and biochemical characteristics. Among these, 40 strains have been identified to species level by 16S rRNA gene sequence analysis.

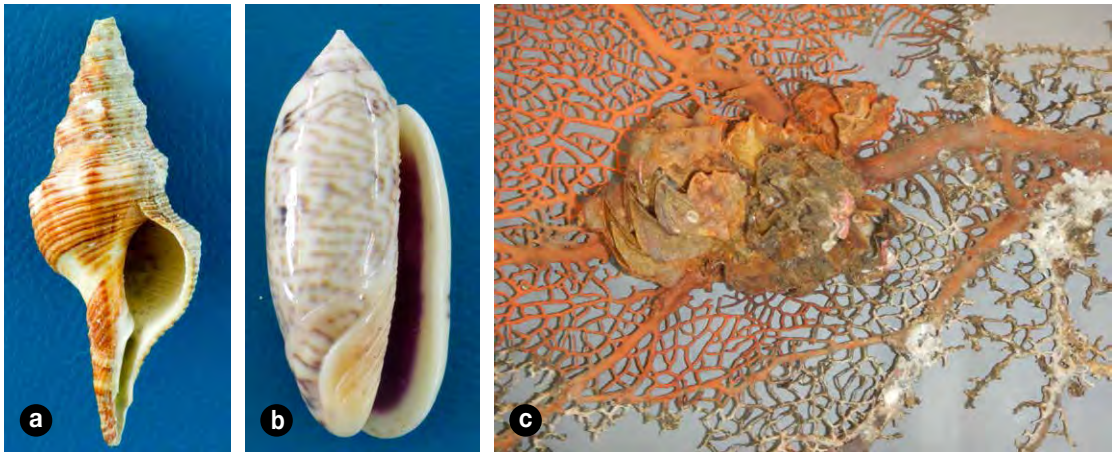
Molluscan diversity

The mollusk resources of Kalpeni and Androth Islands included mostly gastropods and bivalves. In Kalpeni Island, 24 species of gastropods belonging to 11 families were recorded. One sea slug (*Bulla arabica*), One cowrie (*Monetaria caputserpentis*), two cone snails (*Conus arenatus, C. ebraeus)*, three species of muricids (*Semiricinula* sps., *Morula uva, Drupa* sps.), four neretids (*Nerita polita, N. costata, N. antiquate, N. semirugosa*), one naticid (*Polinices lacteus*), one ranellid (*Gyrineum concinnum*), four species of strombs (*Canarium betuleti, C. mutabile, Gibberulus gibberulus, Harpago chiragra*), three species of terebrid (*Oxymeris maculate, Terebra guttata, Terebra punctatostriata*), one species of trochid (*Trochus radiatus*), one species of vase snail (*Vasum turbinellus*) were recorded among gastropods. The bivalves comprised of two species belonging to two families and two genera. *Tridacna* sp. and *Barbatia* sp. were the two species of clams recorded among bivalves.

In Androth Island, 19 species of gastropods belonging to 9 families were recorded. One cowrie (*Monetaria caputserpentis*), four species of cone snails (*Conus arenatus, C. ebraeus, C. betulinus, C. chaldaeus*), three species of muricids (*Semiricinula* sps., *Morula uva*, *Drupa* sps.), four neretids (*Nerita polita, N. costata, N antiquate, N semirugosa*), one ranellid (G*yrineum concinnum*), one species of stromb (*Harpago chiragra*), three species of terebrid (O*xymeris maculate, Terebra guttata, T. punctatostriata*), one species of trochid (*Trochus radiatus*), one species of vase snail (*Vasum turbinellus*) were recorded.

The mollusk resources of Bitra Island included mostly gastropods and bivalves. Three species of bivalves belonging to three families were recorded (*Acrosterigma magnum, Asaphis violascens, Venus* sp.). Among gastropods, 4 species of Strombs (*Canarium betuleti, Gibberulus gibberulus, Harpago chiragra, Lambis lambis*), one species of Muricid (*Chicoreus territus*), 10 species of cone snails (*Conus arenatus, C. aulicus, C. betulinus, C. ebraeus, C. nucleus, C. omaria, C. pennaceus, C. terebra, Haliotis* sp.), One harp shell (*Harpa amouretta*), One turrid (*Lophiotoma indica*), one Naticid (*Mammilla fibrosa*), three cypraeids (*Mauritia scurra, Monetaria caputserpentis, M. moneta*), one volute shell (*Melo* sp.), one mitrid (*Mitra* sp.), two neretids (*Nerita albicilla, N. plicata*), two olive shells (*Oliva caerula, O. vidua*), two terebrids (*Oxymeris maculate, O. feline*), one ranellid (*Septa rubecula*), one trochid (*Trochus radiatus*), one turbo shell (*Turbo marmoratus*), two turbinellids (*Vasum ceramicum, V. terbinellus*).

From the mesophotic reef off Puducherry, one species each of Naphatidae (*Niphates* sp.) and Pseudocerotidae (*Thysanozoon nigropapillosum*), Nudibranch (*Phyllidia ocellata*), and 2



a. *Lophiotoma indica*
b. *Oliva vidua*
c. *Hyotissa hyotis* on *gorgonids*

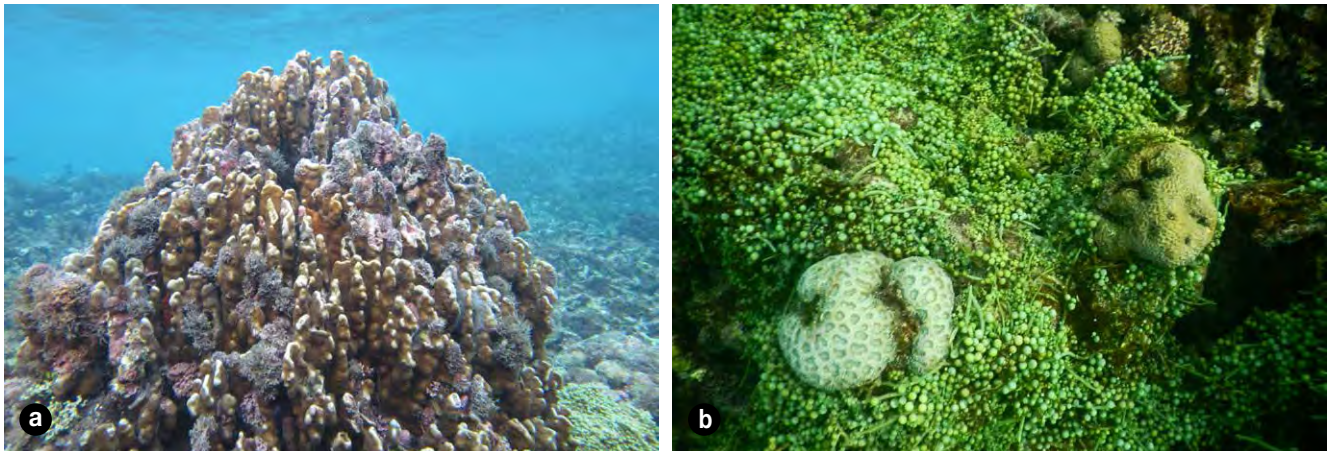
bivalves (*Hyotissa hyotis, Pteria penguin*) were recorded.

Seaweed

Halimeda sp., *Caulerpa* sp., *Gracilaria* sp., *Lithothamnion* sp., *Enteromorpha* sp., *Hypnea* sp.,*Turbinaria* and *Avrainvillea* sp. were recorded. Of these, *Halimeda* sp. was found to dominate in Androth while, *Halimeda* sp. along with *Caulerpa* sp. were dominant in Kalpeni.

Environmental Concerns

In Androth few bleached corals were noticed in boulder and branching forms and diseases were more common in the sub-massive and massive forms *Porites* spp., *Favites* spp., *Platygyra* spp., *Galaxea* spp. In Kalpeni, bleaching was most commonly noticed in Acropoids and diseases were common in the *Porites* genera. Large scale bleaching and ulceration was recorded in *Pavona* sp. Large scale algal infestations (*Caulerpa* sp.) and infestation by encrusting sponges were noticed in *Acropora* spp., *Porites* spp. and brain corals. Disease conditions such as pinking and ulcerative syndrome in *Porites* spp. and *Fungia* sp., tissue loss and white band disease in *Acropora* spp., damage due to trematodiasis, infestation by feather duster worms and predation by giant clam *Tridacna* sp. were noticed. Tissue loss and necrotic patches



a. Pinking and ulcerative lesions in *Heliopora coerulea*
b. Algal infestations and bleaching in *Favia* sp.

were also observed the blue coral *Heliopora coerulea*. Diseases were more common in the *Porites* and *Platygyra* genera in the Bitra Island. Incidence of bleaching is very less in Bitra and can be due to increased depth at which the colonies are found. In Tuticorin Fishing Harbour, bleaching of massive and sub-massive corals like Favids, Dendrophyllids and Poritids was noticed during the month of June and July 2016.

Propagation studies on soft corals

Growth performance of the soft coral *Cladiella laciniosa* in laboratory conditions

The size of the parent colonies in terms of their maximum spread were 166 mm, 194 mm and 233 mm. Concrete blocks and compressed red clay tiles were used as substrata for the attachment of the fragments removed from parents. The fragments showed attachment to the substrata in about twenty days time. However, no differences were observed in the time taken for attachment between the fragments placed on concrete blocks and compressed red clay tiles. The initial growth measurements were recorded after complete establishment of new fragments to the substrata. The survival of explants was 100% and all the sixteen young

colonies were found to be healthy. Initially the number of lobes in fragments of concrete blocks ranged from 19 to 44. After 22 months, the increase in lobes ranged from 179 to 558. The number of lobes in young colonies, grown on compressed red clay tiles ranged from 19 to 52 at the start of the experiment which increased to 215 to 346 after 22 months of culture. The total spread of the newly established colonies ranged from 35 to 45 mm. In concrete blocks, the colonies showed an increase in spread from 136 to 215 mm; while on compressed red clay tile, the increase in spread ranged from 130 to 173 mm.

Propagation studies on soft coral *Sinularia kavarattiensis* at Calicut

A total of thirteen fragments were removed from two healthy parent colonies of *Sinularia kavarattiensis*.The fragments were removed by tying a noose to the selected lobes in the parent colonies. The time taken for the detachment of lobes from the parent colony was about 12 to 14 days, with tightening of noose on alternate days. This method of removal of fragments from the parents helped to minimize the injury to the parent colony. Laterite slabs and floor tiles were used for the attachment of fragments and the time taken for attachment was about 25 days. The survival of newly established colonies was 100%. The increase in the number of lobes ranged from 3 to 6 during a culture period of three months.

Assessment and valuation of coral reef island ecosystem

Research project: FISHCMFRISIL201400100033

Biodiversity of Devagad Island

The biodiversity of the Devagad Island, off Karwar, in Karnataka was assessed. Underwater surveys and mapping of the resources around the island were undertaken. A total of nearly 370 species belonging to over 280 genera, under 220 families, 37 class and nearly 25 phyla were recorded from around the Devagad Island. Fifty-one species of phytoplankton comprising 39 genera under 31 families while 10 genera of zooplankton under 17 families were recorded around the Devagad Island. Finfish diversity comprised of 70 species of fish belonging to 40 genera under 21 families. 22 species of seaweeds belonging to 7 families,

Devagad Island, Karwar

2 species of holothurians, one species of sea urchin, three species of jelly fish belonging to three genera under three families, were recorded. Among corals and gorgonids, 12 species under 11 genera and 11 family and 5 species under 4 genera and 2 families were observed respectively. Four species of zooanthids were recorded. Among arthropods, 23 species under 16 genera and 10 families and 23 species of mollusks under 20 genera and 19 families were recorded. 44 species of other taxa under 33 genera were also recorded. Fourteen species of birds and 23 terrestrial plants were also recorded. Trawl transect surveys were conducted around the Devagad Island to study the diversity and biomass of the demersal fauna during pre-monsoon, monsoon and post monsoon seasons. Over 50 species belonging to 50 genera under 40 families were recorded. The demersal diversity was found to be highest during the pre-monsoon season. During monsoon, the demersal fishes were observed to be concentrated above the bottom layers. The socio-economic status of the fishers operating around the Devagad island ecosystem was assessed. The study indicates that the maximum proportion of fishers had education up to lower primary level (54.5%) followed by Lower Primary section (21.2%), Diploma level (12.1%), High school level (6.1%) and Degree level (6.1%). The analysis of the fishing pattern indicated that about 85% of the fishers operated trawl nets and 15% operated purse seine nets for their livelihood.

Valuation of Devagad Island Ecosystem

Valuation of the Island ecosystem was done as per MEA (UNEP 2006). The valuation of the four ecosystem services provided by the Devagad Island was carried out taking in account all the services provided by the island ecosystem. The economic value of the food (provisioning services) of the Devagad Island is estimated at ₹3669 which includes services from coral reef, food production, raw materials, algal beds, holothurian and rock oysters. The total area of the Island is 9.64 ha which includes terrestrial area (4.64 ha) and rocky shore (4.96 ha). The food value through fish production (fishery) is INR 3647 lakhs. The value of the regulatory services provided by the Devagad Island is INR 3755 lakhs. This includes the primary productivity, forest cover which provides climate regulation and genetic resources such as cliff banana. It also includes nutrient generation from inshore area, nutrient cycling from the algal beds, coral reefs disturbance etc. The value of the supporting services provided by the Devagad Island is INR 38.76 lakhs, which includes services added to the ecosystem through the presence of birds, sea turtle, dolphins, corals, navigation (light house), spawning and nursery grounds. The value provided by the cultural services of the Devagad Island is INR 12.3 Lakhs which includes aesthetic and endangered value of coral reefs, tourism and light house. Thus the total economic value of all the ecosystem services provided by the Devagad Island ecosystem is INR 747.3 million (US $10.9 millions).

DBT funded project on Molecular taxonomy and phylogeny of Cones (cone snails) and Strombs (Mollusca, Gastropoda) of the Indian coast

Research project: EFP-27

A total of 20 species (70 individuals) from the families Conidae and Strombidae were collected from five sampling sites along both the coasts of India, Shakthikulangara and Vizhinjam in Kerala; Chennai, Thoothukkudi and Mandapam in Tamil Nadu. Specimens were identified based on shell morphology; morphometric and meristic characteristics and were recorded. Tissue samples from the region of muscular foot or mantle were taken and preserved in 95% ethanol till further use.

DNA extraction

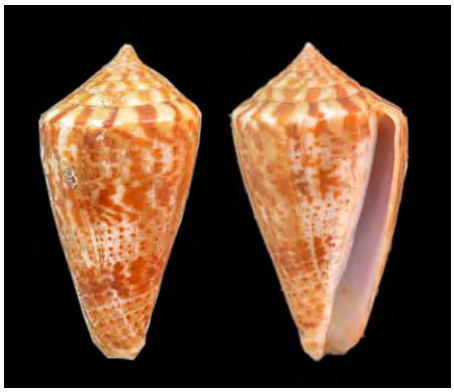
Muscular tissue from the foot or mantle of the Conus and strombid specimens were used for total genomic DNA extraction. A customised marine animal kit, premium according to the manufacturer's instructions (Origin) was used and the DNA isolation was standardised

to obtain optimum quality DNA. The quality and quantity of DNA were tested by Nanodrop (Eppendorf pvt. Ltd).

PCR Amplification

1µl (50-75ng) of DNA from each genomic extraction was used as template for invitro amplification using polymerase chain reaction (PCR). The PCR amplification reactions were performed in a total volume of 25 µl and included master mix (Orion, Origin) in a DNA Engine Thermal Cycler under the appropriate conditions.

Fragments of the mitochondrial genes 12S rRNA, 16S rRNA , cytochrome oxidase subunit I (COI) and nuclear H3 gene were amplified using universal primers 12S1/12SB (Simon, Franke & Martin, 1991; Palumbi, 1996), 16Sar/16Sbr (Palumbi, 1996) , LCO1490/HCO2198 (Folmer et



Conus inscriptus

Conus amadis

Conus araneosus

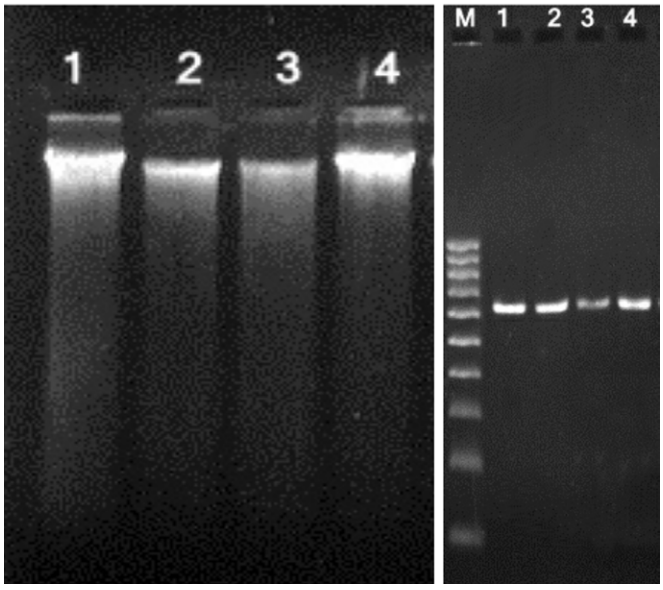
Conus monile

Lambis lambis

Laevistrombus canrium

al., 1994),and H3a/H3B (Colgan et al 1998) respectively. All PCRs were performed in 25 ml, containing 75 ng of, 2.5 mM MgCl2, , 0.3 mM each primer. Amplification reaction consisted of an initial denaturation step at 94ºCfor 4 min, followed by 35 cycles of denaturation at 94ºC for 30 s, annealing for 40 s at 54ºC, 52 50ºC and 52ºC for 12S, 16S COI and H3genes respectively, and extension at 72ºC for 1 min. The final extension was at 72ºC for 5 min. PCR amplification of 70 individuals from 20 species of the families Conidae and Strombidae for all the four genes was completed.

PCR products were electrophoresed and visualised on 1.2 % agarose gels containing ethidium bromide (7 µl). All genes were sequenced at the sequencing facility in both directions for increased accuracy. Sequences were validated using BLAST search within nucleotide database to determine the highest homolog.



Isolated DNA and PCR Amplified CO I (640bp)

Sargassum landings at Mandapam

Marine habitats

Pollution and litter in the coastal and marine ecosystem and their impact

Research Project: FISHCMFRISIL201201600016

Plastics and other non degradable debris from the fishing grounds in different fishing gears were collected for quantification through participatory approach with fishermen.

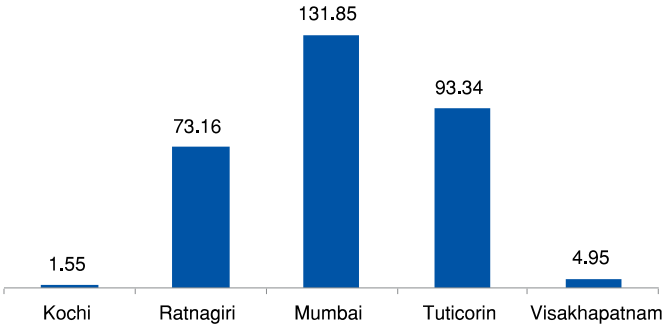
Marine litter in fishing area and fishing gears

Quantity of plastics in the fishing ground off Mumbai, Ratnagiri, Kochi, Tuticorin and

Visakhapatnam ranged between a low of 1.55 kg km^{-2} in the fishing ground off Kochi to a high of 131.85 kg km^{-2} off Mumbai.

In Gulf of Mannar, the quantity of litter was high in gears operating near the sea bottom like mechanised trawlers, and bottom set gill net than other gears, indicating more litter in the

a. Plastics in fish catch off Ratnagiri
b. Plastics in dol net catch from Gujarat



Quantity of plastic litter (kg per km2) in different fishing areas

sea bottom.

Along Maharashtra, shore-seine operated during September 2016 at Juhu, Girgaon, Dadar and Aksa beach indicated that coastal fishing zone near Juhu was the most polluted (6.8 kg per 10 minutes haul). Quantity of litter in dol nets of Gujarat was comparatively lower.

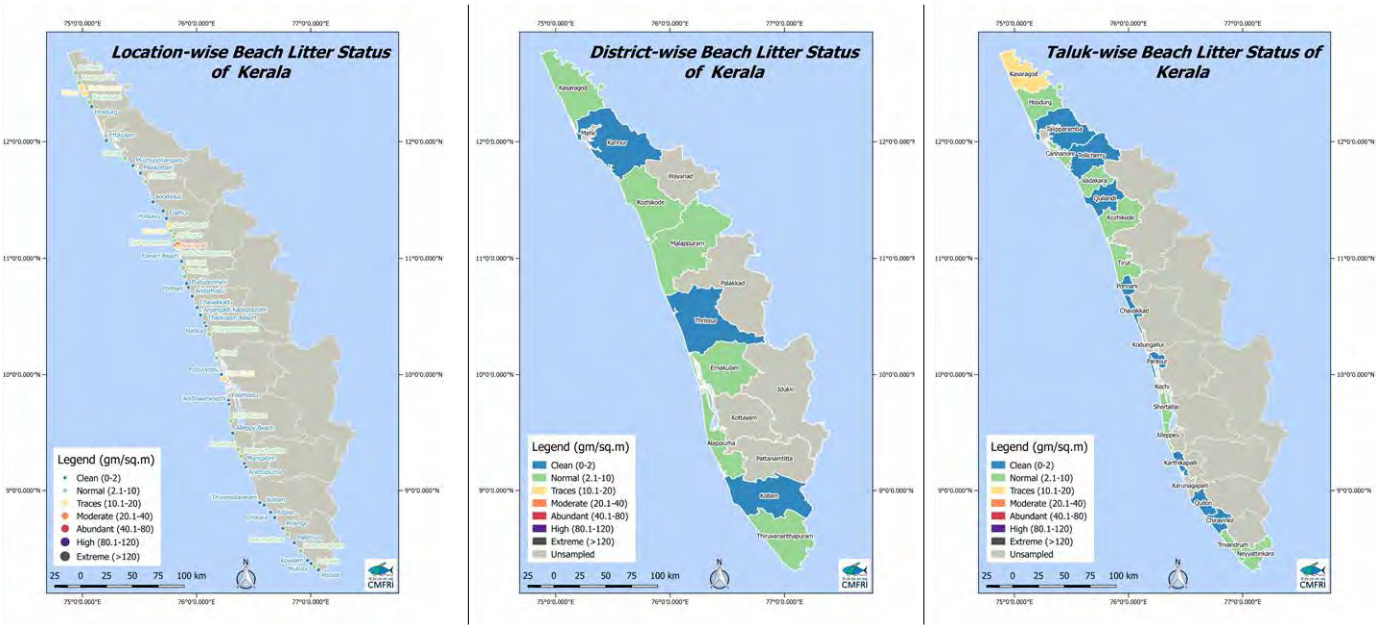
Though plastics were the major component in the litter in fishing areas, net pieces were also high indicating potential threat of “ghost fishing” in all areas. High occurrence of torn nets in marine litter, indicated the need for more awareness programs for fishermen to stop discarding torn nets in the sea.

Quantification of beach litter

From 2011 to 2016, there was a reduction in quantity of beach litter along Karnataka coast. The quantity per square meter at Thannerbhavi beach in numbers (92.43%) and in weight (95%), while at Chitrapur the reduction in number was 88.14% and in weight 95.64%. The reduction was lower at Panambur in number (63.7%) and weight (54.6%). This is mainly because, the traditional fishermen land at the beach with the nets and the litter accumulated in the net is discarded in the beach. This study indicates that there should be a litter collection mechanism from fishers as practised in developed nations.

Agnitheertham beach (near Rameswaram temple) was found to be highly polluted compared to other beaches. Urgent action to control littering and disposal of solid wastes is required.

A synoptic picture was attained for the status and composition of beach litter from 254 select beaches along the maritime States of Peninsular coast of India as well as the Union Territories of Andaman and Lakshadweep Islands from the one time observation. These beaches were



Grading of beaches of Kerala as per non degradable litter

classified and graded with colour codes according to the levels of beach litter. A beach litter grading was done for state, coastal districts and taluks of Kerala. Beaches of very clean grade (<1g/m^2) were found in Kerala (17), Maharashtra (12), Tamil Nadu (2), Andhra Pradesh (4), Odisha (7) and West Bengal (3).

Impact of Litter on critical habitats like mangroves and sea grass

Several patches with high quantities of plastic and other litter were observed in important mangrove areas along Kerala, Karnataka and Maharashtra. Minimum plastic litter observed ranged from 0.88 g m^{-2} in the month October 2016 to maximum 1.94 g m^{-2} in the mangroves at Kasarweli village (Ratnagiri) during December 2016. Sea grass beds of Palk Bay did not have extensive accumulation of substrate litter but had scattered floating and submerged litter. In Kerala, in the Cochin backwaters, anoxic zones and spots without benthos due to litter were observed.

Occurrence of macro plastics in fish gut

Macro plastic of about 3cm length was obtained from the gut of *Euthynnus affinis* collected from the gill netters based at Veraval, Gujarat.

While analysing the gut content in the laboratory, the stomach of one specimen contained

Plastic piece obtained from the gut of tuna, *Euthynnus affinis*

Gut contents of Coryphaena hippurus showing macro plastics

only plastics. Similarly in the gut of *Coryphaena hippurus* plastic piece of about 5cm length and other macro plastics along with snails and digested materials was observed.

Oil pollution

The accidental collision of *MV MT BW Malpe* and *MV MT Dawn Kanchipuram* on 28th January outside Kamarajar Port, Ennore caused oil spill of a minor extent and major panic among the coastal communities. Though the exact amount of spillage was not known, it is estimated that about 65 tonnes of slick was reportedly removed.

A survey was conducted along the coast from Pazhaverkad to Kovalam to assess the extent of damage caused by the oil pollution. Examination of the biota on rocks near Kasimedu indicated damage to sedentary organisms near the HTL. However organism down the LTL was found healthy and unaffected.

Studies on the fly ash deposition rate in the Karapad Bay, Tuticorin

During the period July to December, the impact of the coal based effluents from Tuticorin Thermal Power Station (TTPS) like fly ash containing slurry and hot water discharge and the impact of handling hazardous chemicals through loading and unloading activities on the Tuticorin coastal water ecosystem was assessed. The studies indicated that the effect of fly ash and hot water discharges are more adverse in the Tuticorin coastal waters than chemical release of port activities.

Impact of untreated municipal sewage

The impact of untreated municipal sewage discharge, the high saline effluents from salt pan areas and hot water effluent discharge from a private thermal plant was assessed along Tuticorin coast. The analysis indicated that the coastal water of Pearl City beach, which is under the influence of municipal sewage discharge, is more impacted when compared to other stations.

Total plate count of marine sediment samples of Visakhapatnam coast showed maximum (13 x 106) at the fisheries harbor than the sewage disposal site and a reference sites.

Ecosystem process of critical marine habitats and development of protocols for restoration

Research Project: FISHCMFRISIL201201800018

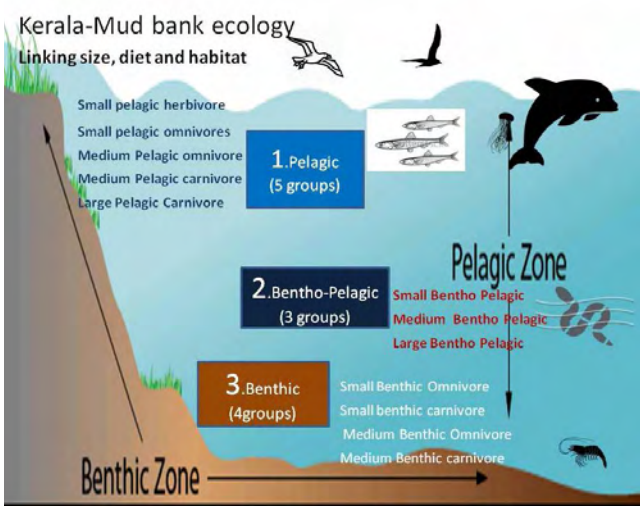
Eco-biological processes of Mud banks of Kerala

The phytoplankton, zooplankton and benthic communities of the calm area (mud bank MB) and non-calm area (NMB) off Alappuzha were highly productive during June and July and these were found to serve as food for low level trophic groups. There was no significant difference between these MB and NMB off Alappuzha indicating that primary food was available uniformly.

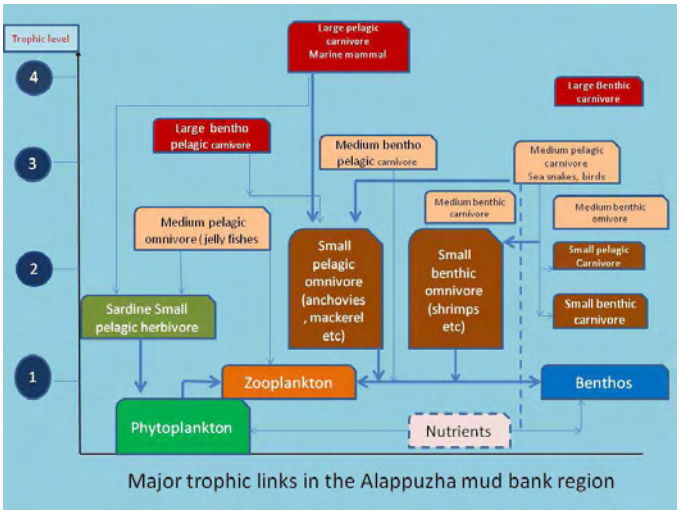
Twelve trophic groups were identified based on diet, size and habitat preference. Among these the community was dominated by small pelagic omnivores (anchovies, mackerel etc), small benthic omnivore (shrimps, crabs etc) and small pelagic herbivore (oil sardine).

Anchovies, mackerel and sardines were found to be in actively feeding state, indicating that rich plankton in the MB and NMB area which supports the high biomass of these resources. Other trophic groups found to feed on these resources (eg Ribbon fishes, Indo-Pacific humpback dolphin etc).

The large biomass of shrimps in the upper column water masses indicated disturbance in the bottom, mainly due to cold and low oxygen upwelled water. Their half filled stomach indicated



Trophic groups in Kerala Mud bank



Food chain in Kerala Mud bank

active feeding. The shoals of all the three groups were found beyond the calm area

Flocking of sea birds (migratory) especially terns and gulls for foraging on anchovies, sardines and shrimps was observed all along Ernakulam-Alappuzha area and their role in nutrient enrichment was also observed.

Noctiluca spp blooms along west coast.

Noctiluca spp blooms were observed in the fishing area along the west coast. The cell density was 13 x 105 cells L-1 in the fishing area off Kochi (09° 58.47 N 076°02.01E) in July, stretching over an area of 3.5 km parallel to the coast. Diatoms belonging to the genera *Rhizosolenia* sp., *Navicula* sp., *Thalassiosira* sp., *Coscinodiscus* sp., *Bacteriastrum* sp., *Pleurosigma* sp. and *Melosira* sp. were also identified. The bloom was observed till September and was observed even in the estuary during low tide but with less density.

Inter-relations between abiotic factors and phytoplankton during post monsoon period.

Five yearly analyses (2012 – 16) was done for delineating the trend on environmental parameters and phytoplankton biomass at 5m depth and 10m depth, off Cochin, during post monsoon (October – January).

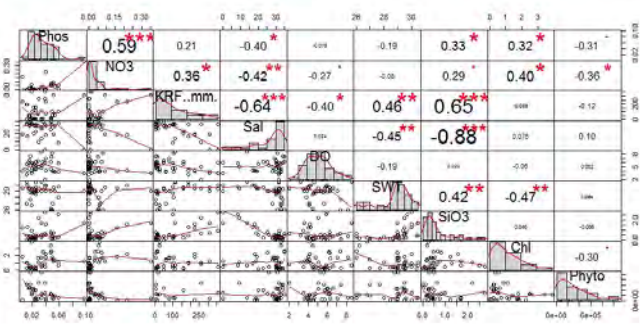
The concentration of phosphate and nitrate at 5 m depth was found to decrease with more fresh water influence, whereas, the silicate concentration increased in October months.

The higher content of nitrate in water in October 2016 can be linked to the positive LTA of 2.16°C, in this region in October 2016, indicating strong upwelling.

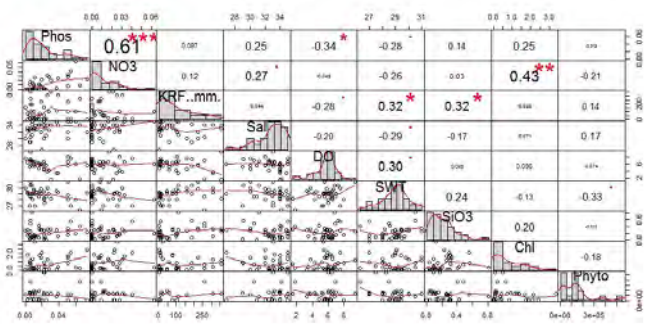
At 10m, there was consistently higher biomass of phytoplankton in November in all years from 2012 – 2016.

Except for the bloom of *Noctiluca* sp in December 2013, January 2015, November 2015 and December 2015, the diatoms dominated the phytoplankton biomass in the months of October to January during 2012-16. In January 2016, Cyanophyceae and Coccolithophore were dominant.

The correlation results in R, gave indication of influence of nitrate on phytoplankton biomass. Influence of silicate and nitrate by rainfall and rainfall influencing water temperature, phosphate



Correlation matrix for environmental paramerts at 5m depth off Kochi



Correlation matrix for environmental paramerts at 5m depth off Kochi

influencing chlorophyll are also indications for environmental influence on phytoplankton biomass and community structure.

Ecology of Sea grass beds

Extensive under-water surveys were conducted in the sea grass beds of Palk Bay. A bivalve *Electroma vexillum* (Recve, 1857) was observed on the blades of three species of seagrass at Hare island. Adults were attached on hebroader leaf-species *Cymodocea serrulata* and *Halophila ovalis* while spat were found on *Syringodium isoetifolium* with narrow leaf blades. This zonation in distribution proved the ability of this species to utilize seagrass leaves as settlement surface selectively as the growth advances.

Electroma vexillum on *Cymodocea* leaf

Restoration of Mangroves

The growth of mangrove propagule planted in a degraded area in Karnataka was monitored, from 2011 to 2016 the average plant height increase from 55.61cm to 140.98cm the average number of branches increased from 1.58 to 34.9 and the average number of leaves increased from 10.17 to 151.28.

The organic carbon content of the sediment was observed to be highest in mangrove planted area 0.31% and least in non mangrove area 0.19%.

For restoration of mangrove in Paradeep a survey work was carried out and discussions were held with the local authorities and a site was selected for planting mangrove saplings (2000 Numbers) which are being maintained in the office nursery at Puri Field Centre of CMFRI.

Sentinel site monitoring in Nethravathi Estuary

Considering the proximity of the clam beds to fish meal plants and to the fishing harbor, the gravimetric analysis of oil and grease in the water samples from the sentinel sites were carried out.

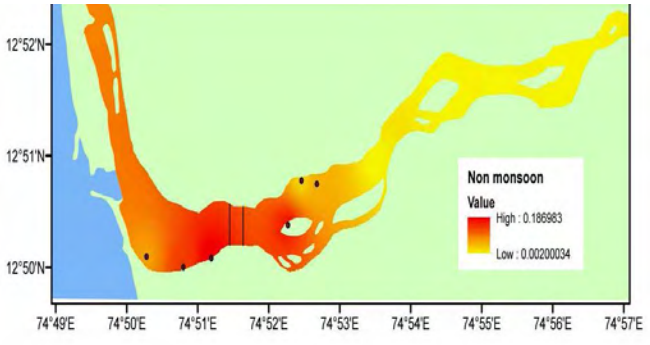
Oil and grease portion varied between 0.002 and 0.223 m l^{-1} during non-monsoon season and between 0.005 and 0.037 mg l^{-1} during monsoon season along a pollution gradient.

Values were highest in Ullal Hoige and lowest in Jeppina Mogaru. The maximum permissible limit of oil and grease in waterbody should be 10 mg l^{-1} as per Environment Protection Act 2002.

Estuary receives effluent from 13 fishmeal plants with a production capacity of 31,950 t year-1 near Ullal Hoige.

The fishmeal plants are in operation during the pre-monsoon season and post-monsoon seasons, and during monsoon the plants are closed.

Bivalve - Electroma vexillum



Distribution of oil and grease in Netravathi estuary

Indian cormorant (Phalacrocorax fuscicollis) in Fishing ground off Gujarat

Coastal and Sea birds

Observation on coastal birds of Gulf of Mannar and Palk Bay at Ramanathapuram marine water/ coastal habitat *viz* Valinokkam mudflats, Kothdaramar koil mudflats, sand dunes near Arichal munai was intensified. The number and diversity of winter migration seabirds were recorded along with geo-referencing.

Storks (Family-Ciconidae) and brown pelicans (*Pelicanus occidentalis*) were observed in Valinokkam mudflats while Greater Flamingo (*Phoenicopterus ruber*) was observed at Valinokkam and Kothandaramar Kovil mudflats. Different gulls (*Larus* sp) were observed in Sand dunes in Arichal munai.

Occurrence of coastal and sea birds along Gujarat and Mumbai coast and fishing area was also documented

Marine mammals

The sightings of dolphins off Kochi were noted during 2016. For the first time, a live porpoise was also observed in this area. Usually stranding of porpoises has been noted along West coast.

Ecological variations in sardine habitats and its impact on sardine fishery in Kerala

The reasons for sardine fishery decline were elucidated. The role of environmental changes in recruitment was analysed. Low upwelling leading to warmer conditions and low food availability were some of the major reasons for poor spawning.

Changes in nutrients and plankton communities/groups in the coastal waters were studied. The results indicated impacts of poor monsoon on the ecosystem. Groups which have benefited from these extreme events have also been identified.

Resource Assessment, Exploitation and Utilisation of marine algae from Indian coasts

Research Project: FISHCMFRISIL201400200034

Wild collection of seaweeds from Tamil Nadu coasts during the year 2016 was estimated as 4316 tonnes dry weight showing 16 % increase over the previous year. The quantity (tonnes dry weight) by species is *Sargassum* spp 2135 t , *Turbinaria* spp 515 t, *Gelidiella acerosa* 344 t, *Gracillaria edulis* 372 t, *Gracillaria salicornia* 950 t.

Kappaphycus production through maricuture during 2016 decreased to 270 tonnes, registring 23% reduction over the previous year.

Sargassum mulch applied in paddy fields

Seaweed landing at Vedalai Tamil Nadu

Basal application of *Sargassum* mulch to paddy in the farmer's field registered marginal increase in plant height (p >05). This treatment increased the Total Organic Carbon content (2.41%) significantly higher ($p < 0.05$) than the control field (1.6%).

Although number of grains/ ear was more in the control plot, mulching *Sargassum* resulted in increase in the weight of grains (0.029g) than the control (0.026g).

Performance of seaweed liquid fertilizer developed by CMFRI when compared with similar product manufactured by commercial entrepreneurs on green chilly showed increase in plant height, leaf area and number of fruits in the plants received foliar spray of SLF developed in our laboratory.

The seaweed products (mulch and SLF) developed by CMFRI are ready for large scale application or farmers' use and can be released.

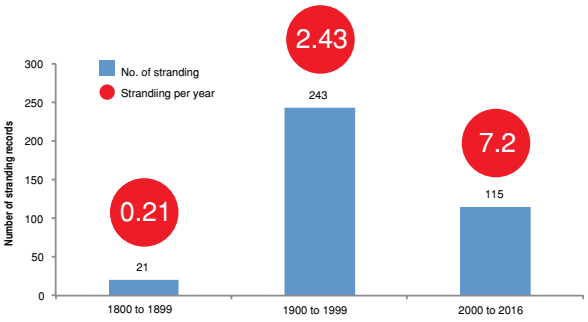
From the Puri Field Centre, seedlings of tomato and brinjal were given to 27 women SHG of Paikasahi village, Panasapada Panchayat to do organic farming using seaweed fertilizer. Liquid seaweed fertilizer and sprayer were provided to each member and weekly data were collected through a social worker of that village. Apart from this, 600 nos. seedlings of tomato were given to three beneficiaries of Rameswarpur and Paikasahi village to take up organic farming in a pilot scale. Regular monitoring of the growth is done by the social worker of that village.

Study on enhancing the effectiveness of conservation potential of marine mammals in Indian seas

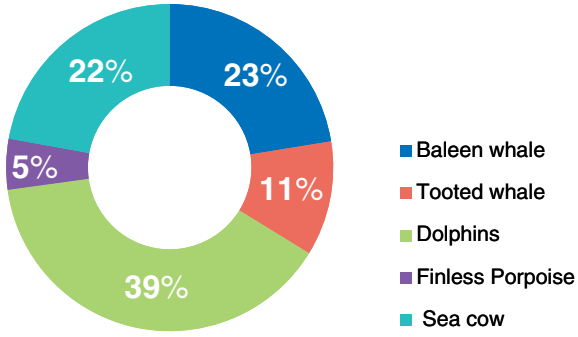
Research project: CP-1006299

Records on marine mammal stranding incidences along the Indian coast for the past 216 years collected and submitted to MoEF.

Analysis of the records on stranding of marine mammals 1800 to 2016 indicated that 25 species consisting of 5 baleen whales, 4 toothed whales, 14 dolphins and one each of finless porpoise and sea cow were reported as stranded along the Indian coast.



Number of marine mammal stranding along Indian coasts during the period 1800 to 2016



Percentage of different marine mammal groups stranded along Indian coast during the period 1800 to 2016

The number of stranding records was only 21nos, (0.2 per year or one stranding in every 5 year) during the period 1800 to 1889 while it increased to 243 (2.4 nos per year) in the succeeding century and during the 16 years since 2000, 115 (7.2 per year) stranding have been reported. This alarmingly high rate is a matter of concern and has to be prevented or reduced at the earliest.

Among the five groups highest stranding was that of dolphins (39%) followed by baleen whales (23%), sea cow (22%), toothed whales (11%) and finless porpoise (5%).

The stranding of baleen whales was recorded in all the maritime states along west coast except Goa, while along east coast (except Tamil Nadu), the stranding records were low. Stranding of toothed whales was highest, along Tamil Nadu (51%) coast followed by Lakshadweep Islands (16%).

Tamil Nadu recorded highest (53%) stranding of porpoises followed by Kerala and Karnataka (16% each). No stranding of Porpoises was observed along Goa, West Bengal, Andhra Pradesh and in the Island territories.

Dugong stranding was observed only from states which have sea grass habitats; Tamil Nadu (79%), Gujarat (14%) and A&N islands (7%).

It was observed that gill nets are responsible for 98.8% of the mortalities and occasional reports of incidental catch / entanglement in trawl, purse seine, shore seine and long line has also been recorded since 1970s.

From 1976 to 2013, about 766 entanglements / incidental catch of dolphins in fishing gears has been reported from Karnataka, Kerala, Tamil Nadu and Andhra Pradesh. Highest fishing related mortality were reported from Kerala (526 nos.) followed by Tamil Nadu (231 nos.).

A total of 45 porpoises have been found to be caught by fishing nets along Karnataka (34nos), Kerala (9 nos; from gill nets) and one each from Gujarat (dol net) and Tamil Nadu (gill net).

Other Activities

Training Program–Out Reach

Training cum Workshop on 'Methods of Ecological Analysis by Statistical Software' was organised from 5th to 11th January, 2017 for staff of FEMD. Experts from Annamalai University, CMFRI, CIFT, NIO and KVASU were invited in addition to faculty from CMFRI. The participants were given hands on training on the use of software like PAST, SPSS, PRIMER and QGIS.

Training for women on eco-friendly bags

Training for 25 women and students were organised in collaboration with St.Marys College, Thrissur for stitching eco-friendly carry bags. Awareness program on the need to reduce of plastics and responsible disposal of the same was also conducted.

Training on making foldable eco-friendly bags

Fish cemetery

The Installation Art 'fish cemetery' was a theme conceived by CMFRI with two of its institutional entities - team Fishery Environment Monitoring Division (FEMD) and team Swachh Baharat Abhiyaan joining hands to create awareness about the growing threat of plastic pollution in marine ecosystem affecting the health of the biota. Studies have clearly indicated that the ecosystems are fast degrading, destroying the habitats which were once productive. The art work, which consists of giant fish like structures, was inaugurated by the worshipful Mayor of Kochi Corporation, Ms. Soumini Jain on January 21, 2017. The 'Fish Cemetery' is a symbolic expression of dead fishes as a drastic impact of the excessive presence of plastic wastes in the sea.

The Installation Art made of iron scrap and jute consisted on one big fish of 12 ft height and 6ft width and 4 medium and 3 small fishes spread over 4000 sq. ft. area at Fort Kochi beach, one of the most popular beaches of Kerala. The artists took sixteen days to finish the art which was observed and appreciated by over 4 lakh people during the period from 21st January to April 30th 2017. This program was implemented in association with Cochin Shipyard Ltd. and the campaign was by Monsoon Productions. This is the third Installation Art of CMFRI, the first one a huge Octopus at Cherai Beach during June 2012 and the second, a "Mad Crab" at Fort Kochi beach in 2013-2014

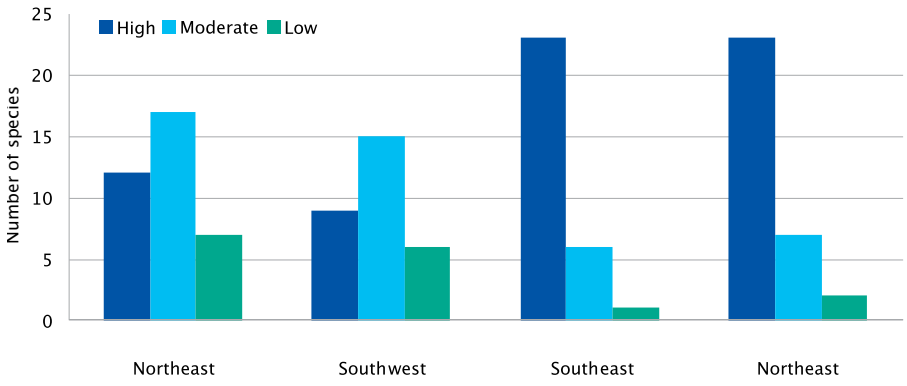
Carbon stock assessment of mangroves

Climate change

Research project: CP-1006299

Impact of climatic parameters on phenology of marine fishes

Related studies undertaken indicates changes of SST, Chl a, current speed, wind and rainfall do have influence on the diet, spawning, maturity, distribution and catch of various marine fishes. The pelagic fishes such as *Trichiurus lepterus*, *Harpodon neherus*, *Sardinella longiceps* and *Rastrelliger kanagurta* are continuous spawners, which gives them high potential to adapt to climatic changes. The demersal fishes such as *Nemipterus japonicus* and *Pampus argenteus*, were found to be less adaptive to climatic variability.



Zone-wise dispersion of species (numbers) based on species vulnerability

Vulnerability assessment of Indian marine fish stocks to climate change

Vulnerability of Indian marine fish stocks to climate change was assessed and brought out as a special publication under the NICRA project. Scientific criteria on exposure, sensitivity and adaptive capacity of Indian species were developed to enable assessment of the vulnerability of fish stock. This also allows for predictive evaluation based on 40 year catch data.

Criteria was formulated as: Vulnerability = (Exposure + Sensitivity)-Adaptive capacity

Vulnerability assessments have been carried out at different centres as per the developed criteria. For this, 40 year's data on fishery biology and environmental parameters of Indian coast were analysed. All the exposure attributes (climatological) were analysed as per the criteria and ranked as low, medium or high. The sensitivity attributes (related to the biological and fishery) of 68 species of fishes/shellfishes which are commercially important was done and ranked. The adaptive capacity attributes (related to its distribution, prey and duration of spawning etc.) were also ranked as low, medium and high.

Species with high vulnerability in 2 or more zones

Species	Zones	No of zones	Major influencing factor	Major gear
Metapenaeus monoceros	SW, SE, NE	3	Life history and fishing pressure	Trawl
Parastromateus niger	NW, SW, SE	3	Fishing pressure (juvenile)	Trawl
Plicofollis tenuispinis	SW, SE, NE	3	Life history and fishing pressure	Trawl
Carcharhinus limbatus	SW, SE	2	Life history	Trawl
Decapteus russelli	NW,SE	2	Fishing pressure	Trawl
Fenneropenaeus indicus	SW,NE	2	Life history and fishing pressure	Trawl
Katsuwonus pelamis	SE,NE	2	Life history and fishing pressure	
Nemipterus japonicus	SE,NE	2	Fishing pressure	Trawl
Penaeus monodon	SE,NE	2	Life history and fishing pressure	Trawl
Sardinella gibbosa	SE,NE	2	Fishing pressure and lack of upwelling	
Saurida tumbil	SE,NE	2	Fishing pressure	Trawl
Saurida undosquamis	SE,NE	2	Fishing pressure	Trawl
Scomberomorus commerson	SE,NE	2	Fishing pressure	
Sphyraena jello	SE,NE	2	Fishing pressure	Trawl
Thunnus albacares	SE,NE	2	Life history and fishing pressure	
Trichiurus lepturus	SE,NE	2	Fishing pressure	Trawl

Carbon stock assessment of mangroves

Studies were carried out to assess the blue carbon potential of mangroves in Kadalundi, situated in the Calicut district of Kerala. A total of six species of mangroves viz., *Avicennia officinalis*, *Rhizophora mucronata*, *Sonneratia caseolaris*, *Bruguiera parviflora*, *Kandelia candel* and *Acanthus ilicifolius* were recorded from the mangrove ecosystem of Kadalundi. Among the six species, *A. officinalis* was the predominant species in terms of number as well as in terms of coverage of area. The mean total biomass was 399.9421 t/ha and the mean total C was 199.9711 t/ha. The overall mean total biomass for Kadalundi mangroves was estimated to be 235.3045 t/ha contributing to a mean total carbon stock of 117.6521t/ha. The above ground carbon pool constituted 71.39% to the total biomass while the below ground carbon pool constituted 28.61%.

Climate Modelling

Environmental parameters such as temperature, upwelling index, chlorophyll, rainfall and wind speed were collected from 1960 to 2011. The sea surface temperature (SST) showed an increase over the years from 1960- 2016 (28.43 ± 0.28° C) with 0.3°C average temperature increase for the past five decades. However, the analysis of last five year data shows increase in the temperature, 28.43± 0.36° C (0.36° C increase in last 5 years). Projections were done for specific regions along the Indian coast, and extension of this work is planned to cover the rest of the coastal states of India.

Changes in distribution and community structure of Zoanthids

Distribution and community structure of zoanthids was studied along three coastal villages of Saushatra coast. Seven zoanthid species were recorded and correlation between different zoanthids species and abiotic factors indicate positive correlation between SST and *Palythoa tuberculosa*.

Higher levels of dissolved oxygen were found to favour the growth of zoanthids like *Palythoa mutuki* and *Isaurus tuberculatus*, whereas *Palythoa tuberculatus* was also found to tolerate increased SST. These results indicate that the community structure of zoanthids might be

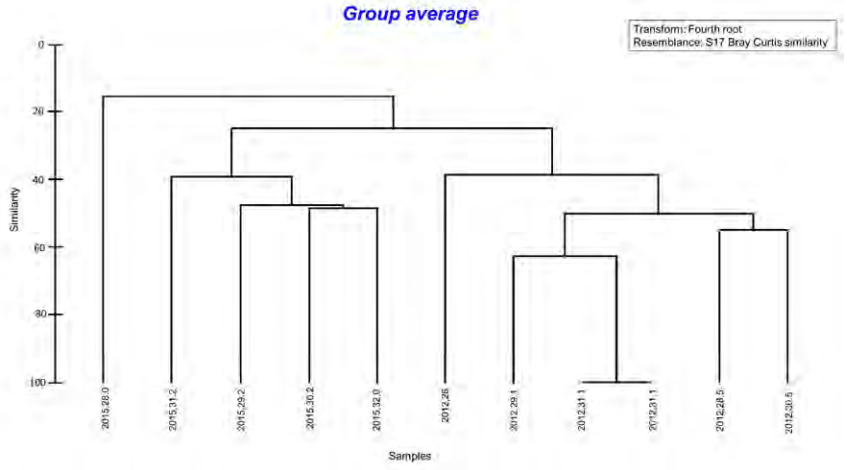
a. Onsite measuring of mangrove plants
b. Photograph showing outgrowth of zoanthids over corals in a degraded reef ecosystem

dominated by species with higher tolerances for increased SST and nutrient levels, and reaffirm the adaptive capacity of zoanthids to environmental changes, which similar corals lack.

Changes in phytoplankton community in relation to SST in sardine habitat

The major species of phytoplankton in the community during 2012 (when sardine was abundant) was compared with that of 2015 (when there was sardine scarcity). *Melosira sulcata* which usually does not dominate the community was found to dominate in 2015 when the SST was high.

Hierarchical Cluster analysis revealed the connectivity of clusters of phytoplankton species at



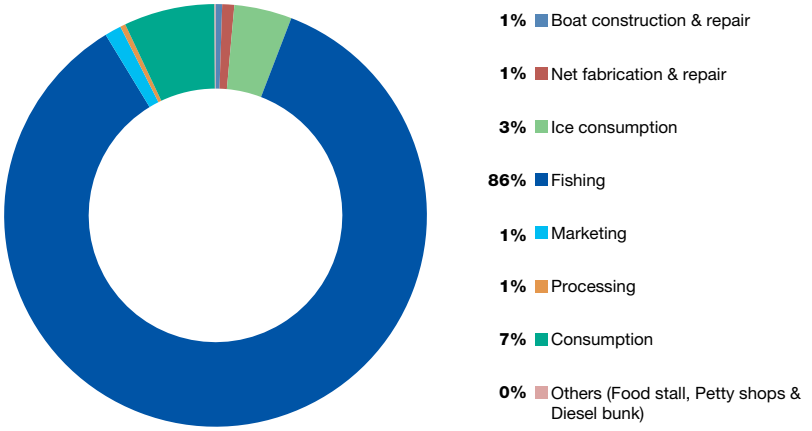
Results of Hierarchical Cluster Analysis on changes in phytoplankton communities in relation to SST

specific mean SST. The horizontal lines in the dendrogram are drawn at the levels of similarity between clusters indicating similarity in species composition.

The species diversity was found to be high in 2015 when nearly 90 diatom species were found to occur in the habitat. The number of Dinoflagellates was also found to be high during 2015. This may be due to low predation as a consequence of low biomass. The inference is that with higher SST, phytoplankton species which are more tolerant will dominate.

Life Cycle Assessment

The impact and carbon output of the fishery industry in various fishing centres across India was calculated, and the major source of atmospheric carbon dioxide from the fishery industry



Carbon footprint by marine fishing in Chennai

was found to be the harvesting phase, emanating from the combustion of fuel and operation of fishing paraphernalia with trawlers emitting the highest amounts of carbon.

Major source of carbon in the pre-harvesting phase is contributed by boat building and net preparation. Wood acts like a carbon sink as it accumulated carbon during photosynthesis and hence shows negative carbon foot print when used as a construction material in place of other materials like FRP, PVC or concrete.

Carbon in harvesting phase contributed by the fishing process includes the combustion of fuel used for propulsion and the entire fishing operation. Major source of carbon in post harvesting phase is influenced by the supply chain. In the event of local circulation for domestic market the carbon input per Kg of harvested fish is credited by transportation and storage using ice. However, in case of distance circulation and export the major carbon input is contributed by processing plant, transportation and cold storage.

Mariculture

Carbon Sequestration Potential of Seaweeds

Experimental studies were conducted on assessment of carbon sequestration potential of seaweed (*Kappaphycus alvarezii*) and found that the total amount of CO_2 sequestered into the cultivated seaweed in the year 2013 and 2015 in the coastal districts of southern Tamil Nadu was estimated as 1.38 million and 0.32 million kg respectively. The specific rate of sequestration (per unit mass of seaweed per unit time) of CO_2 by the seaweed was estimated as 0.0187 g/day-1.

Kappaphycus alvarezii shows significant carbon sequestration potential

Technology Demonstrations

Integrated Multi Trophic Aquaculture

Successful conduct of three demonstrations on Integrated Multi Trophic Aquaculture (IMTA) under participatory mode with a fishermen group at Munaikadu (Palk Bay), Tamil Nadu by integrating seaweed *K. alvarezii* with cage farming of Cobia (*R. canadum*) were done. The demonstration of seaweed cultivation with cage farmed cobia yielded almost double the weight of seaweed and more number of apical portions than the conventional seaweed cultivation. The apical portions could be used for replanting further more number of crops.

a. Sea weed culture integrated to cage farming
b. View of seaweed and harvested cobia

Training Programs and Technology Transfer

Cage farming of high value fish, the sea bass *Lates calcarifer*, cobia *Rachycentron canadum* and Pompano (*Trachinotus blochii*) were demonstrated to farmers and other stakeholders from stocking, feeding, growth measurement, environment monitoring to harvest by using different types of cages. Low cost cages were constructed using GI pipes and floated on HDPE barrels, and provided with one outer and one inner net. This technology demonstrated to common fishermen makes cage culture affordable to them.

a. Low cost square cages
b. Low cost circular cages
c. Integration of fin fish with paddy and shrimp in pokkali fields

Vulnerability Assessment of coastal fishing communities – IDLAM

Using PARS (Parameter, attribute, resilient indicator and score) methodology, vulnerability indices were constructed for vulnerable coastal areas. This is used for prioritisation and ranking of different impacts as perceived by fisher folk, facilitating for assessment of the awareness, preparedness and viability of mitigation measures available to vulnerable communities, ultimately forming the Integrated District Level Adaptation and Mitigation framework to combat the deleterious effects of climate change.

Economic sustainability and trade

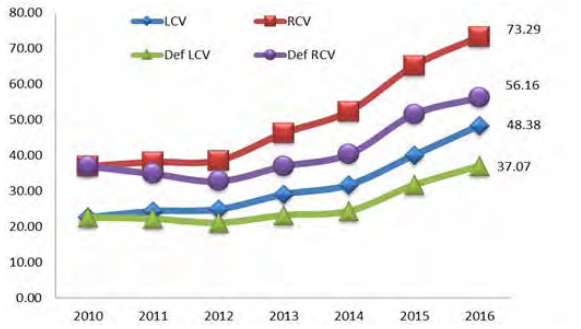
Valuation of marine fish landings, economic performance and supply chain management

Research Projects: FISHCMFRISIL201202200020 and FISHCMFRISIL201202200023

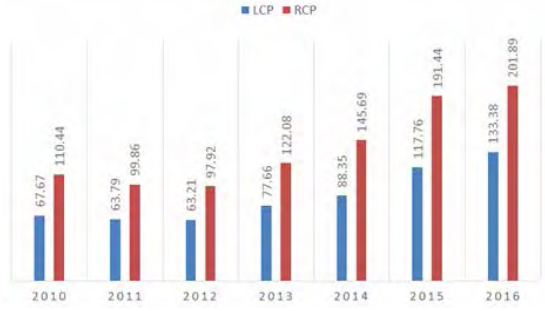
Valuation of marine fish landings and inventories

The estimated value of marine fish landings during 2016 at landing centre level was ₹ 48,381 crores, (20.69 % increase over 2015) and at retail level, realised ₹73,289 crores (12.44 %

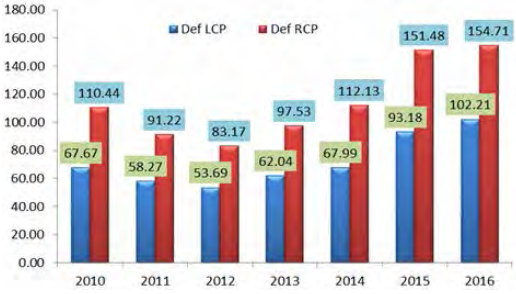
increase over 2015). The unit price / kg of fish realised at landing centre was ₹133.38, (13.18 % increase over 2015) and at the retail market level was ₹201.89 (5.46 %) increase over 2015)



The value of marine fish landings deflated with the base year 2010 is given below



The unit price realised at the point of first sales and last sales deflated to the 2010 base year



1b. Species-wise Valuation of marine fisheries in India

Though the prawns (both penaeid and non-penaeid) share about 10.18 per cent of the volume of landings, they contribute 17.66 per cent in value of the landings (11.21 %–penaeid and 6.44 %t -non penaeid). Due to reduced share of the sardine landings in 2016, their share in value came to an all-time low of 2.97 per cent.

Species wise share in Quantity and Sales (in per cent)

Species	Share in quantity	Share in point of first sales	Share in point of last sales
Indian mackerel	6.87	5.67	6.8
Oil sardine	6.75	2.94	3.01
Ribbon fishes	5.98	4.49	4.44
Penaeid prawns	5.51	10.96	11.47
Other sardines	5.38	3.63	3.2
Other perches	4.71	4.42	4.43
Threadfin breams	4.69	3.73	3.74
Non-penaeid prawns	4.67	6.39	6.5
Croakers	4.35	3.26	4.31
Bombay duck	3.99	1.65	1.88
Squids	3.17	3.92	3.89
Scads	2.89	2.17	2.15
Cuttlefish	2.8	3.16	3.4
Lizard fishes	2.61	1.84	1.92
Hilsa shad	2.58	4.65	4.15
Silver Bellies	2.56	1.44	1.44

State-wise valuation across the value chains

The state wise valuation of the fish landed at the point of first sales and the last sales indicated that the highest landing centre valuation was realised at Kerala followed by Gujarat. However it was found that the valuation at the point of last sales registered the highest value in Gujarat followed by Kerala, Tamil Nadu and Karnataka.

State-wise valuation of marine fish landings (thousand crores)

State	Landing centre valuation			Retail Centre valuation		
	2015	2016	% change	2015	2016	% change
Kerala	9574	9149	-4.44	14641	12398	-15.32
Gujarat	7027	8427	19.92	11700	13130	12.22
Tamil Nadu	5634	6492	15.23	9650	10728	11.17
Karnataka	4617	6247	35.3	7694	9108	18.38
Odisha	2480	1645	-33.67	4020	2836	-29.45
Maharashtra	4626	5369	16.06	7490	8313	10.99
Andhra Pradesh	3048	2516	-17.45	4828	3916	-18.89
West Bengal	1220	5501	350.9	1560	8190	425
Goa	1060	997	-5.94	2150	1451	-32.51
Daman Diu	620	1433	131.13	1066	2351	120.54
Puducherry	190	605	218.42	380	868	128.42
Total	40095	48381	20.67	65179	73289	12.44

Gross valuation of inventories in marine fisheries sector

The estimated valuation of inventories in Indian marine fisheries sector 2016-17 worked out at ₹23,668 crores during 2016-17, about five per cent higher than 2015-16 estimates. The value of the inventories was highest in the mechanised sector at ₹21,759 crores (91.9 % of the total investment) followed by motorised sector at ₹1, 549 crores (6.54 %) and non-mechanised crafts at, ₹360 crores (1.52 %).

Gross valuation of inventories in marine fisheries sector (thousand crores)

Year	Valuation of inventory-Investment (₹)	Valuation at LC level (₹)	Return over investment	Valuation at Retail level (₹)	Returns over investment
2014	21,023	31,754	1.51	52,363	2.49
2015	22,662	37,317	1.65	64,593	2.85
2016	23,668	48,381	2.04	73,289	3.09

Among the maritime states, Gujarat accounted for the maximum share of valuation of inventories with 26 per cent of the total investment, followed by Tamil Nadu with 16.8 per cent and Maharashtra with 16 per cent.

Macro indicators of marine fisheries sector in India

Macro Indicators	Value
Value at landing centre (in crores)	48,381
Total operating cost (in crores):	27,093
Net operating income: (in crores)	21,288
Total valuation of inventories (in crores)	23,668
Gross ratio	2.04
Capital Productivity	0.56
Gross value added (In crores)	22,899

The macro indicators of marine fisheries sector in India indicates that the value (in crores) at landing Centre is higher at ₹48,381, followed by gross value added is ₹22,899, total operating cost is 27,093, total valuation of inventories is ₹23,668, net operating income is ₹21,288, the gross ratio is 2.04 and with capital productivity of 0.56.

Economic performance of fishing methods

In Gujarat, the capital productivity was highest (lowest operating ratio) for the multi-day trawling of more than six days duration (0.27) followed by mechanised doll-netter (0.22). The gross value added was maximum in case of multi-day mechanised trawl (>6days) at ₹4,35,718.

Economic performance of fishing methods (per trip) in Gujarat

Economic indicators	MDT (>6d)	MGN(SD)	Mot.GN (2-5 d)	Mech.Doll net (2-5d)
Total operating costs	215782	5220	3200	22389
Gross revenue (in ₹)	598500	6160	5662	101988
Net operating income	382718	940	2462	79599
Capital productivity	0.36	0.85	0.57	0.22
Labour productivity (kg/crew)	399	14	19	256
Input output ratio	0.27	0.34	0.28	0.16
Gross value added	435718	4060	4062	85199

MDT- Multi Day Trawl, MGN – Multi Day Gillnetters Mot. GN – Motorised Gillnetters SD – Single Day

In Maharashtra, the capital productivity was highest for the multi-day purse seining (2-5 days) at 0.12 followed by single day mechanised trawling (0.13). The gross value added was maximum in case of multi-day purse seining (2-5 days) at ₹5, 03,447.

Economic performance of fishing methods (per trip) in Maharashtra

Economic indicators	MDT (>6d)	MDT (2-5 days)	MDT (SD)	MPS (2-5 d)	MPS (SD)
Total operating costs	223201	104666	25945	108649	42635
Gross revenue (in ₹)	629756	466869	142870	573696	154590
Net operating income	406555	362203	116925	465047	111955
Capital productivity	0.35	0.22	0.18	0.19	0.28
Labour productivity (kg/crew)	392	232	146	249	71
Input output ratio	0.30	0.17	0.13	0.12	0.20
Gross value added	442393	387766	124625	503447	124205

MPS – Mechanised Purse Seine

In Kerala, the capital productivity was highest for the mechanised single day gillnets fishing at 0.55 followed by single day mechanised multi-day gillnet fishing. (0.56). However, the gross value added was maximum in case of multi-day gillnet (>6days) at ₹4.37.510.

Economic performance of fhsing methods (per trip) in Kerala

Sl. No	Economic indicators	Multi day Trawling (2-5)	Multi day Trawling (>6D)	Mechanised Gillnet(SD)	Mechanised Gillnet(MDF>6D)
1	Total Operating costs	78903	280913	107941	351658
2	Gross revenue (in ₹)	125132	490586	197500	632092
3	Net Operating income	46228	209672	89559	280434
4	Capital productivity	0.63	0.57	0.55	0.56
5	Labour productivity (kg/crew)	99	252	146	240
6	Input out put ratio	0.29	0.25	0.20	0.31
7	Gross value added	88962	366748	158631	437510

In Tamil Nadu, among the mechanised fishing, the capital productivity was highest for the mechanised single day trawl net fishing at 0.62 followed by single day mechanised shrimp trawl (0.66). The gross value added was maximum in mechanised single day trawl net fishing at ₹28, 304.

The capital productivity was same at 0.48 for both dingle day and multi-day trawling (2-5 days) in Andhra Pradesh among the mechanised fishing. However the gross value added was maximum in multi-day trawling (2-5 days) at ₹1, 12,158.

Economic performance of fishing methods (per trip) in Tamil Nadu								
Economic indicators	Mech.trawl (Shrimp)	Mech. Trawler (SD) fish	Mot. MDG	Mot. MDT	Mot. BSGN	Mo.Other BSGN	NM-BSGN	NM-OBSGN
Total Operating costs (₹)	24937	28896	30679	28148	1415	1638	302	285
Gross revenue (in ₹)	38286	48764	49644	43939	2148	2502	621	543
Net Operating income	13332	19891	18965	15791	733	868	319	259
Capital productivity	0.66	0.62	0.64	0.67	0.74	0.71	0.49	0.53
Labour productivity (kg/crew)	81	240	43	78	4	11	2	6
Input out put ratio	0.5	0.42	0.45	0.49	0.49	0.48	0.25	0.31
Gross value added (₹)	19,034	28,304	27,213	22,476	1,092	1,309	469	383

In Odisha, among the mechanised fishing, the capital productivity was highest for the single day mechanised purse seine fishing at 0.30 followed by multi-day trawl (>5days) fishing (0.54). However, the gross value added was maximum in multi-day trawl (>5days) fishing at ₹3.04.410.

Economic performance of fishing methods (per trip) in Andhra Pradesh				
Economic indicators	MDT (SD)	MDT (2-5)	Mot.GN (SD)	Mot. MDGN
Total operating costs (in ₹)	18891	66348.1	8967	18194
Gross revenue (in ₹)	39718	137312.7	18154	35384
Net operating income (in ₹)	20827	70964.6	9187	17190
Capital productivity	0.48	0.48	0.49	0.51
Labour productivity (kg/crew)	151	270	80	131
Input output ratio	0.18	18	0.19	0.21
Gross value added (in ₹)	32,741	1,12,158	14,633	27,805

Economic performance of fishing methods (per trip) in Odisha					
Sl. No.	Economic indicators	MDT(>5 ays)	Mech.Purse seine (MPS)	MPS-Muli-day	NM-SDF
1	Total Operating costs	181496	32531.16	172885.2	289.5857
2	Gross revenue (in ₹)	404912	109563.1	292724.5	5519.7
3	Net Operating income (in ₹)	223416	77031.94	119839.3	13469
4	Capital productivity	0.54	0.30	0.59	0.41
5	Labour productivity (kg/crew)	304	110	327	48
6	Input out put ratio	0.25	0.11	0.33	0.39
7	Gross value added (₹)	3,04,410	97,443	2,92,725	8,239

Price behaviour of marine fish varieties

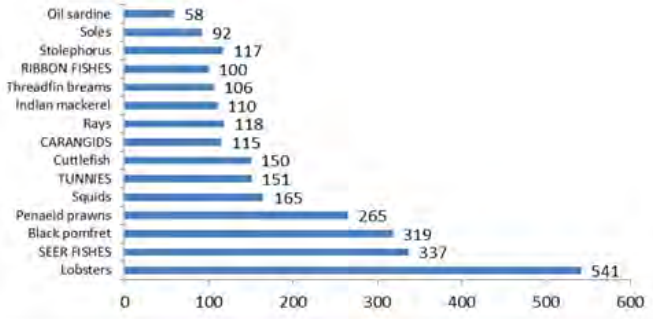
The price behaviour of the marine fish varieties across the landing centre and the retail center is indicated below

Average landing centre price realisation

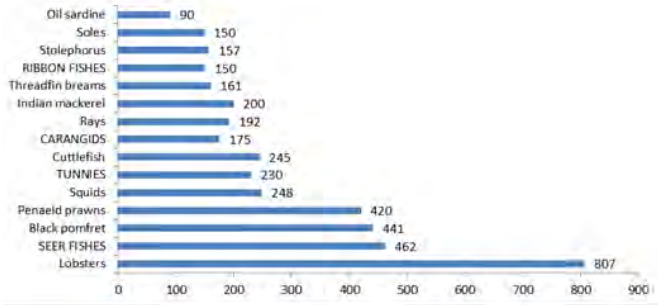
The average landing centre price for major species in India revealed that there is a wide variation in prices across species. The landing Centre price ranged from ₹58/kg for oil sardines to ₹541/kg for lobsters followed by seer fishes at ₹337/kg and Back pomfret, ₹3171kg.

Average retail centre price realisation

The average retail centre price for major species in India indicates that lobsters realised the highest retail at ₹807/kg followed by Seer fishes (₹462/kg) , while oil sardines realised the lowest price of ₹90/kg.



Average landing Centre Price realisation – All India (₹kg)

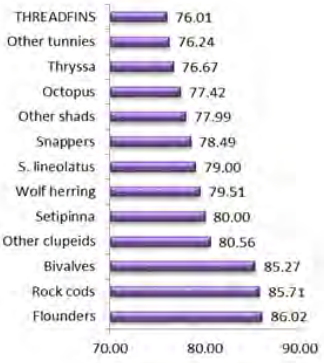


Average Retail Centre Price realisation – All India (₹kg)

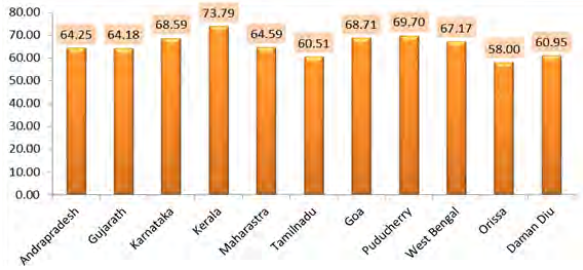
Marketing efficiency

Marketing efficiency is measured as the fishermen share of the consumer's rupee (FSCR) across the major species. The marine fish marketing efficiency across the different states in India indicated that Kerala registered the highest (73.79 per cent) and Odisha the lowest (58 per cent)

Based on the marketing efficiencies across the major species, they were grouped into high market efficient and lower market efficient as given below.



High market efficient (FSCR %)



Average Market efficiency – All India

Low market efficient (FSCR %)

Fish arrival to Kerala

The study analysed the quantum of fish, different species and the States from where it is being sourced to Kerala through a rapid assessment of the fish trade in the major 20 wholesale markets situated in Southern, Central and Northern parts of Kerala. According to the study, the gap between demand and the supply of domestic fish in Kerala is getting wider on a daily basis, revealing that 40 per cent of Kerala's fish demand is met through the arrivals of fish from other States *viz.*, Karnataka, Tamil Nadu, Andhra Pradesh, Goa, Gujarat, Maharashtra and Odisha.

In Kerala the domestic price recorded a fall of 15 to 20% in 2016 compared to 2015 (where retail prices shot up by 30-40 per cent) which is higher than the increase in landings. The study found that Karnataka topped the list of the States from where fish arrives to Kerala by contributing 150-160 tonnes (22 per cent of total arrivals) followed by Tamil Nadu and Andhra Pradesh. As many as 23 fish species are being sourced into Kerala for trade and consumption from different States. Among the different fishes, sardine contributes the mainstay of the arrivals (37.4 per cent of the total arrivals). The study advocates the need for governmental intervention in fixing (minimum support price (benefit of fishers) and maximum ceiling price (benefit of consumers) so that fish being used as non-food and fish food security concerns can be checked.

Impact of demonetisation in domestic fish trade & consumption

A rapid survey was conducted during 24-26 November 2016 to assess the effect on demonetisation of the ₹1000and ₹500 currency bills on the marine fishing operations, trade and fish consumption across different landing centre and markets in Ernakulam.The study analysed the extent of different fishing operations by mechanised, motorised and non-mechanised sector in the landing centres/harbours of Munambam, Chellanam, Fort Cochin, Cochin Fisheries Harbour and Kalamukku. The study covered 200 respondents, the traders from the Broadway, Thevara, Thoppumpady, Chambakkara and Kaloor fish markets were interviewed for assessing the status of the business during these days. Consumer opined their pattern of fish consumption during the period.

The analyses on the fishing operations indicate that there weren't any considerable reduction in fishing operations consequent to demonetisation process. However, there was a marginal decrease in the multi day fishing operations during this period. The study revealed that for the realisation of the labour involved, the crew allowances alone was provided by the commission agents as subsistence and the crew share of the fishermen on account of the catches was delayed for a future payment.

The results indicated that reduction in the revenue earned from the landings ranged between 8 and 16 per cent ranging from 8.28 per cent in the case of single day trawlers to 15.79 per cent in the case of Inboard ring seine. There was a 15-20 per cent reduction in the landing Centre price of major species due to inconsistent or precautionary demand. The retail prices of the fish species was reduced by 30-40 per cent on account of lower demand from the consumers. The consumption of fish came down by 30-40 per cent during the above period.

The most unique thing which was noticed consequent to the demonetisation reform in the fisheries sector was the continued utilisation of the social capital "trust" among the different stakeholders (boat owners, commission agents, labourers and traders) in ensuring that the fishing operations and trade were not affected.

Average price realisation of species traded during pre and post demonetisation period (₹

Species	Pre demonetisation	Post demonetisation
Sardine	141.67	110.83
Mackerel	161.67	132.92
Threadfin breams	160.00	125.00
Black pomfret	355.67	315.00
Red snapper	246.67	216.67
Anchovy	150.00	120.00

Social Capital (TRUST)–rules the roost in the fishing sector–Trust among different stakeholders (boat owners, commission agents, labourers and traders) kept the fishing operations at bay during demonetisation

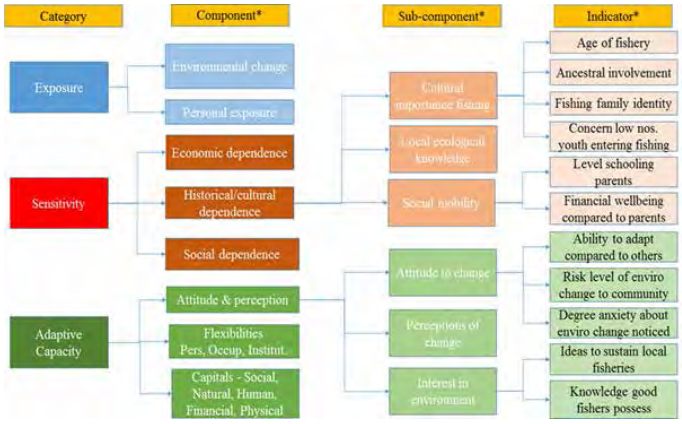
Global understanding and learning for local solutions: Reducing vulnerability of marine- dependent coastal communities (GULLS)

Research Project: EFP-12

The research outputs of the projects are grouped into different heads.

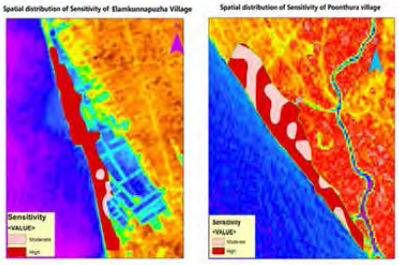
Socio economic vulnerability assessment

An integrated conceptual framework was developed for assessing the coastal community vulnerability by assessing the ecological vulnerability in the economic framework. The three

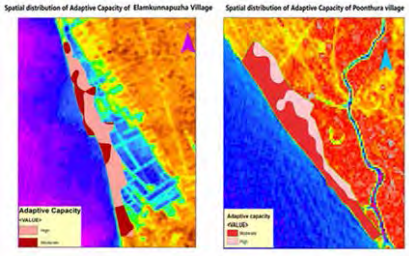


Components of Integrated Framework

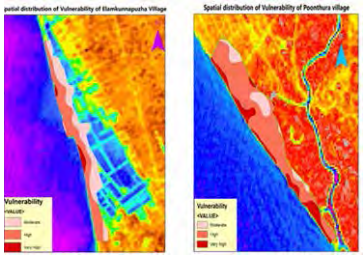
Spatial distribution of Exposure along Elamkunnapuzha and Poonthura



Spatial distribution of Sensitivity along Elamkunnapuzha and Poonthura



Spatial distribution of Adaptive Capacity along Elamkunnapuzha and Poonthura



Spatial distribution of Vulnerability along Elamkunnapuzha and Poonthura

major categories of integrated framework includes exposure, sensitivity and adaptive capacity. (Framewok)

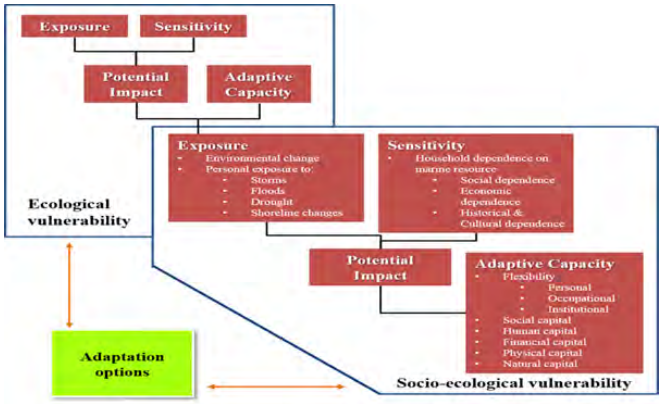
Coastal Vulnerability Index (composite of sensitivity index, exposure index, and the adaptive capacity index) was calculated for the identified marine hotspots of India, *viz*., Elamkunnapuzha and Poonthura/ Beemapally panchayats. A composite vulnerability index was prepared using 198 indicators were identified and constructed. by the following methodology. The methodology used 36 attributes for exposure, 37 for sensitivity and 126 for adaptive capacity. The vulnerability, exposure, sensitivity and adaptive capacity were mapped using Open domain Quantum GIS (QGIS). In addition the individual household vulnerability indices were calculated and based on the frequency distribution (Likert's scale) they were classified into low, moderate, high and very high for which geo-spatial analysis was done. The vulnerability of Poonthura (2.85) was found to be higher than Elankunnapuzha (2.80). The results revealed that majority of the fisher households in both the villages were highly vulnerable to climate change which is a major cause of concern. The overall vulnerability of the regions was assessed and the analysis revealed that the Poonthura was more vulnerable when compared to Elankunnapuzha.

- It was found that about 35 per cent of the population in Elamkunnapuzha is coming under moderate category, 64 per cent of them under high and 2 per cent of them under very high category. On comparison in Poonthura, 18 per cent of the population is represented under moderate category, 63 per cent under high and 18 per cent under very high category. A GIS plot was mapped to see the spatial distribution of households near the coastal area. The results indicate that the population adjacent to coastal areas is more vulnerable when compared to those residing farther thus, indicating a prominent shift in the spatial distribution. Thus, the coastal side of Poonthura region is inhabited by the very high vulnerable group compared to Elamkunnapuzha where there is less percentage of very high category. However both the regions have

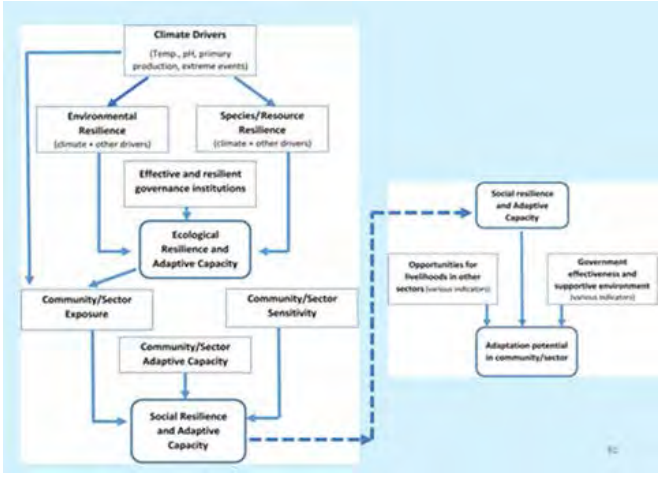
almost equal percentages of high vulnerable population contributing to the increasing vulnerability index.

Frameworks developed

- Developed Governance: Policy mapping document for Indian fisheries sector was developed.
- A balancing of results approach methodology was developed for planning climate change adaptation and mitigation
- The potential complexities of climate change interactions and their possible impacts in mainstreaming the cross-sectoral responses into governance frameworks was developed reviewing the global and national climate change conferences and policies and with the available literature, using a livelihoods framework. Identified the pathways through which climate variability and change impact the fisher folk livelihoods at the household and community level.
- A strategy was conceptualised for planning and implementing village level adaption and mitigation plan through sensitizing and improving the resilience of community towards climate change and initiating a multi stakeholders platform for developing a climate knowledge and information systems; CReVAMP' – "Climate Resilient Village Adaptation and Mitigation Plan" which is facilitated using multi stakeholder governance model by bringing different stakeholders together to participate in the dialogue, decision making, and knowledge sharing and there by instigate knowledge generation process within the community during the course of the process which



Conceptual framework for assessing coastal community vulnerability



Integration and Synthesis framework

is directed to create village information system within the community, enable green fishing practices and prepare adaptation and mitigation plan for a community which would in turn helps in community empowerment, thus enabling in building resilient community /Climate Change Informed Fisher Community (CCIF) and they are expected to influence the society and government in decision making and actions related to climate change mitigation and would eventually be able to influence the policy making process.

- Blue economy and its potential as an innovative method in ensuring economic growth and employment was assessed by defining its strength, weakens, opportunities and limitations. The blue economy growth focus areas and its sectors were identified.
- A conceptual framework encompassing the different indicators components fitting the vulnerability assessment using sensitivity, adaptive capacity and exposure was developed to arrive at socio ecological vulnerability.
- A climate change integration and synthesis framework using drivers resilience (environmental,

ClimEd series-Malayalam version

species/resource resilience) coupled with exposure, sensitivity and adaptive capacity to arrive at social resilience and adaptive capacity in identifying opportunities and government effectiveness was developed.

Communication

- Communication tools to create awareness about climate change were developed in the name "*ClimeEd* series". *ClimeEd* series 1-5 were developed with vernacular support in Malayalam and Tamil in addition to English and Hindi. These instructional materials are developed as a means to create awareness and impart climate change knowledge across the target populace. The *ClimeEd* Series includes *ClimeEd* I (Know your warming planet), *ClimeEd* II (Learning & Coping Climate Change), *ClimeEd* III (Societal role in curbing climate change), *ClimeEd* IV (Climate change and Policy) and *ClimeEd* V (Households in combating climate change).
- A GULLS website termed marine hotspots (networking across global marine hot spots was developed (http://www.marinehotspots.org/index.php/featured-projects/gulls). The website caters to showcasing climate change and its different initiative across the different hotspots by the different partnering research institutions and countries.

Workshops

A Climate Change Awareness Workshop was held at Beemapally UPS, Thiruvananthapuram district on the 11th of May 2016 in collaboration with Poonthura, Beemapally Corporation and State Fisheries Department. The workshop was mainly meant to create awareness about climate change on what is climate change and its possible impacts and how the fishers as an individual, house hold, community and society could take part in developing climate adaptation and mitigation plans. The study focus to develop CReVAMP (Climate Resilient Village Adaptation and Mitigation Plans) for the coastal villages using a bottom up approach and with the proactive participation of the experienced fishers, committed women, articulate children and proactive youth. The workshop comprised inaugural session and technical sessions with 315 registered participants. The participants comprised fisher folk across different sectors as well as leaders representing various self-help groups, local self-government officials, state fisheries officials, elected ward representatives of Beemapally and Poonthura Corporation in addition to Belmont project staff – scientists and project associates.

Linkages

Linkages were developed with the local self-governments at Poonthura, Beemapally and Manikkavilakam corporation wards in Thiruvanathapuram district as a part of imparting awareness on climate change to the fisherfolk.

A meeting was conducted in Elamkunnapuzha grama panchayat in connection with providing alternative livelihood options and climate information kiosks to the fishermen community in the presence of President, Secretary and other ward members of Elamkunnapuzha panchayat.

a. Conceptual framework for assessing coastal community vulnerability
b. Linkages with Local self-governments in Thiruvananthapuram and Officials of Department of Fisheries

Fishery governance, livelihood, gender and welfare

Impact Assessment of the Capacity Development Tools

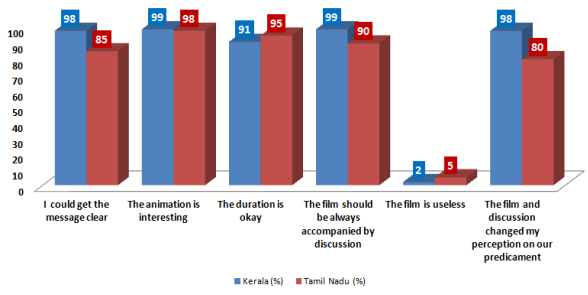
Research Project: FISHCMFRISIL201202200022

The CD tool box was enriched with four video films on topics like alternative livelihood options, Gender issues, Conservation, and responsible fisheries to a total of 11 different communication instruments. The vernacular versions of the animation film on the theme of tragedy of the

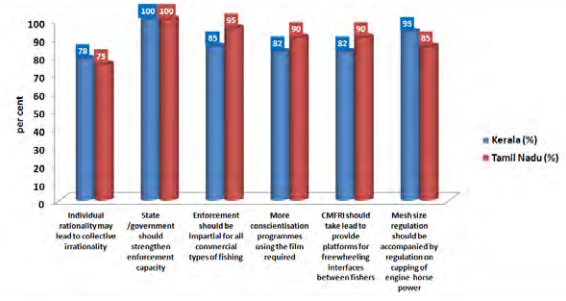
Four films in the C D Tool Box

commons were subjected to impact analysis based on two major approaches 1) assessing the cognitive changes of respondents on awareness and knowledge level pre -and post the interface activities conducted in Kerala and Tamil Nadu and 2) Hermeneutic Frame Analysis (HFA) done in Kerala.

The effectiveness of the animation film, when assessed on six dimensions was found to be highly encouraging. Similarly the affective strength of the film by way of the responses on six "insight /learning statements" was also found to be of high magnitude. That the respondents could grasp the core message of a dichotomy between individual and collective rationalities was the most significant one.



The effectiveness of the communication tool

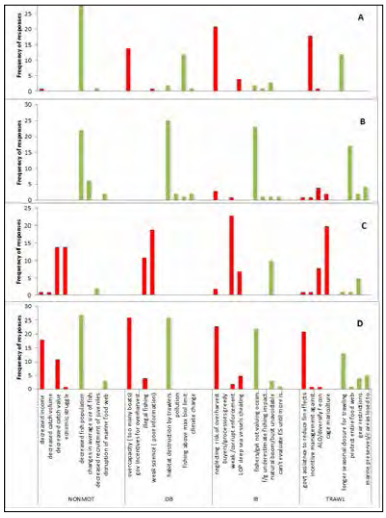


The affective strength of the communication tool

An innovative attempt (HFA) was made to assess the extent to which four categories of respondents in Kerala (non-motorised /Thermocol boats, Out Board Units, In Board units and Trawl boats) resorted to the use of two hermeneutic frames (Bodony 2014 modified). It was found that the respondents across the four categories have resorted to varying degrees of using both ecological and economic frames. But the shift towards the increasing usage of ecological frames augurs well for making more CD oriented engagements with the stakeholder constituency towards engendering EBFM based responsible fisheries.

Impact of management interventions

The alternate day fishing method practiced in Ramanathapuram district was found to be an effective management intervention as revealed ty the respondents. About 95 per cent of the respondent's informed that this practice has completely avoided the conflicts between trawlers and small-scale fishing vessels while 60 per cent expressed that there is an income for motorised sector.



Hermeneutic Frame Analysis – A) Non Motorised) B) OBM C) IBM D) Trawler

Table 1 Respondents perception on effective management intervention

S.No	Effectiveness of management interventions	Percentage of response
1.	Completely avoided the conflict between trawlers and the small-scale fishing vessels	95
2.	Increase in income for motorised sector	60
3.	Increase in number of craft and gears	45
4.	Involvement in alternate options	20
5.	Migrated to others areas due to lack of employment in mechanised sector	10
6.	Increase in employment for traditional sector	30

In Taaruvaikulam (Tuticorin district) the use of passive gears and avoidance of trawl gears as a management intervention has yielded good results as felt by the respondents. About 85 per cent of the respondents expressed that this practice has reduced the diesel expense while 80 per cent expressed that they avoided the conflicts with trawlers from other villages. Seventy five per cent of the respondents expressed that they were able to attain a sustainable harvest of fishery resources.

Table 2 Respondents perception on effective management intervention

S.No	Effectiveness of management interventions	Percentage of response
1.	Sustainable harvest of fishery resources	75
2.	Increase in income	70
3.	Reduction in diesel expenses	85
4.	Fishermen share in retail price is more	60
5.	Conflict with trawlers from other villages	80

Livelihood effects of closed fishing season and their impact on resource use in Kerala funded by Michigan State University, USA

The research determines how women and men adapt differently to livelihood constraints during the seasonal ban, including any pressures they may place on other natural resources during this period. The impact assessment of the seasonal fishing ban study were analysed from 1800 households of the coastal villages of Chellanam, Puthen Kada, Malippuram, Elankunnapuzha, Narakkal, Amasheri and Saudi and the different alternative livelihood options of the fisher folk during the seasonal fishing ban were identified during two time periods – pre ban (June 2016) and post ban (Nov- Dec 2016).

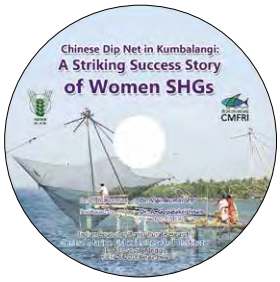
The study highlights the necessity of examining gender and livelihood adaptations to the economic stresses incurred as a result of the resource regulations and understanding why people adapt and cope the way they do. The impact assessment of the social capital of the fishers and fish workers from both formal and informal exchange networks were analysed to check the individual's involvement in raising the social capital which highlights male members migrate to other villages to work during the past 12 months.

Gender mainstreaming in marine fisheries sector

Research Project: FISHCMFRISIL201202200035

An assessment of the performance level and extent of empowerment using indices from Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Odisha was made among 750 Self Help Groups (SHGs).

Identified the relevant fishery based micro enterprises catering to the location specific needs of the SHG members and imparted 33 Entrepreneurial Capacity Building (ECB) Training programmes



by appropriate HRD intervention methods and organised 96 fisherfolk interaction meetings.

Imparted training and done video documentation on Clam Processing SHGs in Pookaitha of Alappuzha, Dry fish SHG units in Sakthikulangara of Kollam, Sauparnika and Vandanam SHGs of Narakkal and Malippuram engaged in Aquatourism, Nithyaharitha Karshakasangham, Karshakasree Vanitha Karshaka Sangham SHG units on Fish Amino Acid production in Elamkunnappuzha, Theeramythri sea food kitchen SHGs in Poyya of Thrissur and Pookode of Vayanadu under SAF

In Andhra Pradesh, assessed the impact of SHGs and organised farmer interaction meetings and conducted video documentation for women SHGs of Bandarvanipetta of Sreekakulam district, Chinthappally of Vijayanagaram district and Pudimadakka, Lawson's bay and Jalaripetta of Visakhapatnam district

Table 1: Micro Enterprises and details of SHGs covered

Sl.No	Enterprise	Number of SHGs	Mean Level of Performance	Mean Empowerment Index
1.	Fertifish unit	15	72.75	0.82
2.	Chinese dip net	10	79.16	0.89
3.	Aqua-tourism	8	78.92	0.88
4.	Fish Aggregating Devices	10	79.95	0.89
5	Hand picking fishing unit	15	50.11	0.65
6.	Clam processing	75	56.33	0.67
7.	Pickling unit	75	72.26	0.83
8.	Fish drying	60	69.95	0.78
9.	Dry fish & fresh fish procuring	45	79.53	0.87
10.	Fish vending /selling	70	69.16	0.78
11.	Mussel culture	50	75.95	0.84
12.	Prawn culture	30	59.61	0.69
13.	Quarry fish culture	16	78.75	0.89
14.	Cage farming	27	72.23	0.82
15.	Ornamental fish culture	49	63.5	0.74
16.	Fish culture	30	65.5	0.76
17.	Paddy cum fish culture	30	74.91	0.83
18.	Seaweed farming	30	77.63	0.86
19.	Fish Amino units	10	75.35	0.84
20.	Ready to Eat Fish Products	15	74.36	0.83
21.	Ready to Cook Fish Products	20	71.35	0.81
22.	Crab Processing	15	68.34	0.77
23.	Aquaponics	5	70.21	0.61
24.	Bivalve collection	30	69.16	0.77
25.	Fish feed production	10	59.25	0.61

Documented 87 success cases on ECB of SHGs with special reference to gender perspective. Brought out 20 movies as Gender Mainstreaming series on Success Stories of Impact of SHGs, one book on 'Gender Mainstreaming and Impact of SHGs in Marine Fisheries Sector' and one 'Interactive Multimedia on Gender Mainstreaming and SHGs: A Cyber Extension Package'.

2b. Women Empowerment and impact Assessment of Society for Assistance to fisherwomen (SAF) functioning

Performance appraisal of Theeramythri initiatives in Kerala –A benefit monitoring assessment and visioning for the future.

Project Code: EFP-25

The project funded by SAF, Department of Fisheries, Kerala, probe to assess the benefit monitoring and evaluation of Theeramythri activity groups and in identifying policy inputs in developing a road map for its future plan and action (Vision-2030).

The performance appraisal of the activity groups aimed to identify the critical attributes determining the performance / non-performance of the micro enterprises as well as the role / performance of the different stakeholders /members in the functioning of the units and other value chain players from 480 sample units covering different enterprises. Statistical and economic tools such as percentage analysis, Garrett ranking technique, and factor analysis have been employed to analyse the data. The study identified that, at the initial stages SAF motivated the fisherwomen to be a part of the theeramythri activity groups through opportunity guidance meets conducted in different districts but now the interactions with the mission coordinators form the major part of group identification. Garrette ranking technique was used to analyse the reason for joining with SAF and clearly states that "Alternative livelihood "is the prime reason for the respondents of both innovators and laggard joining the SAF activity groups, followed by "Economic benefit". The asset to turnover ratio was calculated which measures the efficiency of a group's use of its assets to product sales and found that innovators have high asset ratios when compared to laggards.

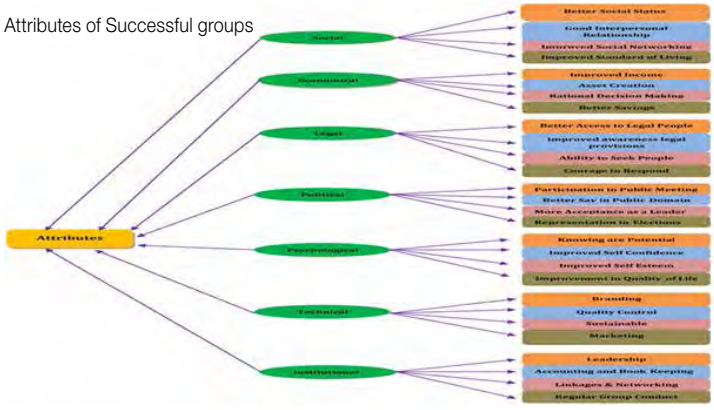
Attributes of successful group

Successful groups are those who are motivated, engaged and aim to achieve at the highest level. The study of SAF-theeramythri project elucidates that all those innovator groups are the successful activity groups.

Analyzing coherence among the group members

The Pearson correlation in identifying the perception of the leaders and followers of the activity groups in its functioning indicated that the relationship between the leader and follower is high

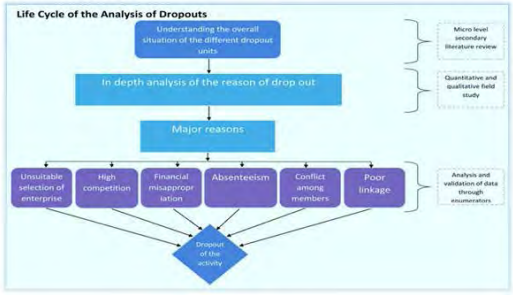
Attributes of Successful groups



for the decision making (0.41) and least for conflict management (0.29) which has a huge impact in the effective functioning of an activity group. The Garette ranking and the correlation analysis revealed the high interrelationship of the members and the followers of the activity groups.

Attrition in fisherwomen activity Groups

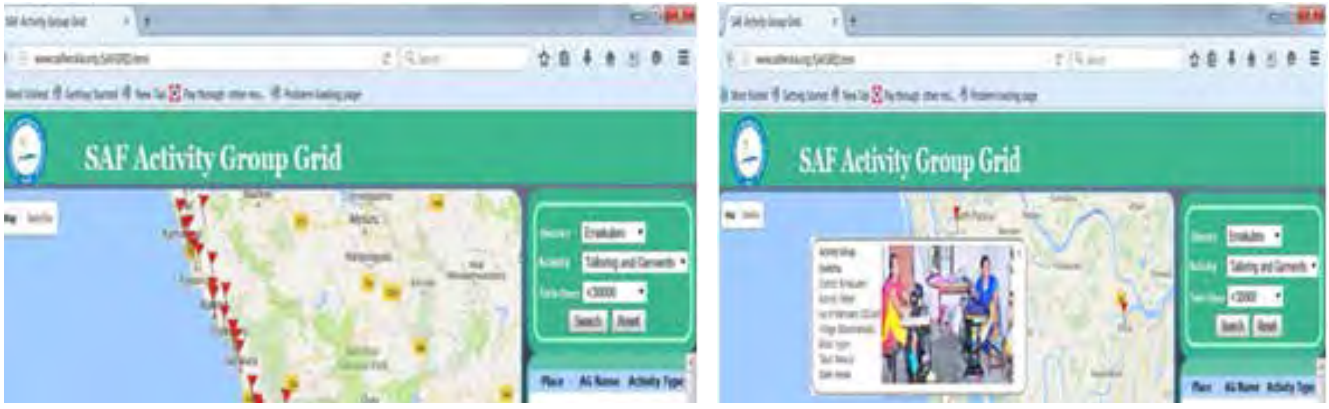
Identified the attributes determining the non-performance and the role of different stake holders in the non-functioning of the micro enterprise units from 90 closed units. The reason for the discontinuation of the units and to develop corrective mechanisms by understanding the flaws in monitoring and implementation process was the objective. The low economic performance (67.87) was the major reason for the closure of activity groups. whereas some of the groups closed down due to the low technical performance (61.92) followed by social performance (60.33) and Institutional performance (58.99).



Life cycle of the analysis of Dropouts

SAF- Activity Group Grid (SAF-AGG)

SAF Activity Group information system was developed as a Decision Support System on a spatio-temporal platform (using GIS and MS Access). The SAF grid encompasses different activity group structure information related to group activity location, group name, group photo, activity, year of start, number of members, access and monthly turnover. This tool identifies stake holders to navigate to locations to identify other group members and their various activities and to exercise economies of scale in business operations.



SAF Activity Group Grid

Policy elements- Vision 2030

Developed the policy statement – Vision 2030

Vision statement: Forging ahead with women for sustainable fisheries and fisher Welfare. Eighteen policy elements were developed to provide a roadmap for evolving an action plan for SAF-2030.

Theeramythri Information on Monitoring and Evaluation System. (TIMES Register)

CMFRI has developed a book of accounts called TIMES register which is implemented in all activity groups to record their daily cash/credit transactions which is mainly intended to increase the accountability and transparency in the working of the units. This register will help the group members to project their credit worthiness while availing bank loans and other credits from financial institutions.

Theeranaipunya –II Skill Enhancement and Capacity building of fisher youth

The two month capacity building training Programme on "Theeranaipunya II was conducted for 35 educated unemployed young fisherwomen which was funded by the Society for Assistance to Fisherwomen (SAF). The thematic areas of the training programme include: profiling, understanding and improving self, aptitude, motivation and personality development, interpersonal relationships, management strategies, communication and audio visual communication, insight into fisheries enterprises and alternate livelihood options. The training included two phases each lasting for a month; Phase I- Inferential learning through class rooms and Phase II –Experiential learning through in-situ training. Inferential learning was from 5th November 2016 – 6th December 2016 at CMFRI headquarters. 25 training centres were identified meeting the educational background and requirements of the trainees was from 7th December to 7th January 2017.

Theeranaipunya II

Status of Fisheries Insurance in India

Research Project: FISHCMFRISIL201202200020

The status of fisheries insurance in India was assessed. The types of insurable risks in marine & inland capture fisheries and mariculture & open sea cage farming were identified. It was found that though there is fair coverage of personal accident insurance programs in some southern states through the intermediation of fisheries cooperatives, the penetration of marine hull, gear or equipment insurance is hardly at satisfactory levels. Similarly, household asset insurance coverage against unforeseen natural disasters, to which most of the coastal families are routinely exposed to, is abysmally low. Most of the available insurance schemes in the capture sector are operated by government owned insurance companies, with the presence of private players hardly recognizable

The analysis of the constraints in marine fisheries insurance indicated that factors such as high insurance premium rates, high perceived hassles associated with insurance, lack of confidence on claim settlement procedures and related factors are identified as the main

Present status of fisheries insurance in India

Sector/Enterprise	Types of risks insurable	Level of risk*	Present status in India
Marine /Inland Capture Fisheries	Life/disability of fishermen/boat crew	Medium	Central Government schemes available in all states but with differential level of penetration. Fairly high coverage in Kerala and Tamil Nadu.
	Partial/complete damage of fishing vessels	Medium	Level of insurance coverage negligible. Only complete damage of hull/engine covered by most policies. Scanty in inland fisheries.
	Fishing gears	High	Only miniscule numbers of independent schemes are in offer. Certain vessel policies also cover gears but with extra premium. Not in inland fisheries.
	Large scale stock decline of fish species due to environmental phenomena/overfishing	Medium	No schemes available presently either in marine or inland fisheries.
	Coastal assets of fishermen	High	A few schemes offered by private companies in liaison with NGOs in the recent past.
Mariculture / cage culture	Marine cages	High	No schemes available presently.
	Inland cages	Low	No schemes available presently.
	Marine / Inland fish crop	High	No schemes available presently.
	Farmed bivalve stock	High	Only selective coverage available.

*Assessment based on field survey

reasons for poor penetration of insurance among the fisher folk.On the part of the insurance industry, besides high risk perception, profitability concerns, high chance of moral hazards and lack of adequate data about disaster risks are the dissuading factors, among others.

Agricultural Technology Information Centre

Technology advisory services

- Technology advisory services were given to 15,393 stakeholders who visited the institute and 630 people were benefitted through sale of technology products during 2016-2017. Fishermen and Department of fishery officials from Kerala, Karnataka, Goa, Odisha & Maharashtra and fish farmers visited the Institute. They were provided the technological information through interactive sessions, demonstrations, video shows, arranging visits to various labs, biodiversity museum, aquarium, technology museum, and publications of the Institute.
- The fisherwomen self-help group members were supported through sales promotion oftheir value added products.
- Feedback on institute technologies collected through bilingual feedback form, training needs were assessed and information transferred to respective Divisions of the Institute.

Revenue generation through ATIC

Coordination/ participation in Exhibitions (Chronological order)

- Albertian International Educational Expo 2017" at St.Alberts College, Ernakulam from 24-01-2017 to 28-01-2017.
- National science Expo during the 29th Kerala science congress at Marthoma College, Thiruvalla from 25-1-2016 to 31-01-2016.
- Exhibition during the inauguration of platinum jubilee of CMFRI on 18.2.17 at CMFRI, Kochi.
- Exhibition stall in Krishimela conducted in connection with the "National meet on prospects of coconut sector in India" at CPCRI Kayamkulam from 29.9.16 to 30.9.16. The programme was inaugurated by Honourable Minister of state for Agriculture and Farmers welfare Shri. Radhamohan Singh on 29.9.16.
- Science exhibition at St.Peters College, Kolencherry from 22.9.16 to 23.9.16.

Annual revenue of ₹5.24 lakhs was generated through (i) sale of institute technology products, services and souvenirs through ATIC (₹3.46 lakhs) and (ii) visitor's fee (₹1.78 lakhs) in 2016-17.

Sl. No	Particulars	Revenue generated(₹	No of farmers/ others benefitted
1.	Products		
	a) (Ornamental fish seed)	27350	23
	b) Algae/zooplankton	7660	18
	c) VARNA fish feed	50090	224
2.	CDs	1300	18
3.	Posters	66150	148
4.	Souvenirs	12145	50
5.	Testing/ Diagnostic services	179868	19
6.	Others	1723	130
7.	Total	346286	630

- Mary's school Thamarachal, Ernakulam on 20.11.16.
- Sanskrit School, Tripunithura from 28.11.16 to 29.11.16.
- Krishi Unnathimela at IARI, New Delhi.

Training and Interaction

- Ten days on –the- job training programme through ATIC from October 24th to 4th Nov for 79 vocational higher secondary students from Kaippamangalam, Thevara and Kadamakkudi VHS schools on Advances in capture fisheries and aquaculture. More than 80 per cent of the students belonged to fishermen communities. Dr.N.Aswathy was the Course Director and Dr.P.Shinoj was the Co-CourseDirector of the programme
- Six days training programme on "Marine fisheries and mariculture research in India" for final year B.F.Sc students from College of fisheries, Kamdhenu Viswavidylaya, Chhattisgarh through ATIC from 20.2.17 to 25.2.17. Dr.N.Aswathy was the course Director and Smt.K.P.Salini was the coordinator of the programme.
- An Interactive session for students under the "Skill mentorship for innovative life experience-16" programme of Higher education department, Kerala was organised on 5th April, 2016 through ATIC.
- One-day training programme for the trainees from KITCO was organised through ATIC.

Intellectual property management

Institute Technology Management Unit (ITMU)

ICAR has decentralised the mode of filing patent and delegated the Director, ICAR-CMFRI to file patent applications directly to the territorial patent offices in Chennai. The patents are being filed through ITMU (Intellectual Property Management and Technology Transfer/Commercialisation Unit). All actions pertaining to the filing of IPR applications and their follow up under the law including maintenance of IPR and further management of IP are being undertaken by ITMU.

Functions of ITMU

- IP protection, maintenance and management
- Carry out internal examination before filing patents
- Patent filing; invite expert opinion from patent attorney/IPR expert
- ITMC duly records the reasons for acceptance/rejection of each patent proposal
- Correction/ rectification/ updation of primary information
- Technology transfer/ commercialisation

Management of IP portfolio (during 2016-2017)

IPRs	Application/ Registration No.	Name of Innovation/Technology	Status
Patents	201711018741	A process to prepare anti-dyslipidemic concentrate from seaweed and a product therof	Application filed
	201611004807	A process and formulation to prepare vibrio antagonistic micro feed for fin fish and shell fish larvae using marine bacteria and a product thereof	Application filed
	201611003277	Primers for single tube reverse transcriptase-loop mediated isothermal amplification as well as a kit and method for detecting beta nodavirus infection	Application filed

The Hon'ble Governor of Kerala releases Cadalmin™ Anti-Hypercholestrolemic Extract, a neutraceutical product developed by ICAR-CMFRI during Platinum Jubilee celebrations of the ICAR-CMFRI at Kochi on 18th February 2017 (Patent Appl. No. 201711018741)

The official launch of "β Nodadetect" a fish virus diagnostic kit, by Dr. Trilochan Mohapatra Secretary, DARE and Director-General, ICAR during his visit to ICAR -CMFRI on 18th April, 2016 (Patent Appl. No. 201611003277)

Overview of IP assets		
No. of technologies licensed	:	5
No. of patents (applied)	:	24
No. of Trademarks	:	1
No. of Copyrights	:	4

Publications under ITMU

- Lavina Vincent, A. Gopalakrishnan and Kajal Chakraborty 2017. Gene patent data mining: An Indian perspective. Presented in NextGen Genomics, Biology, Bioinformatics & Technologies Conference, 3-5 October 2016, Le Méridien Kochi, Kerala.
- Vikram Singh, Kajal Chakraborty and Lavina Vincent 2016. Patent Database: Their Importance In Prior Art Documentation and Patent Search. *Journal of Intellectual Property Rights,* 21: 1-15
- Vikram Singh, Kajal Chakraborty, C. Lavina Vincent 2017. Pharmaceutical patenting trends on drugs and lifestyle diseases: An analysis of Indian and global status. *Current Science*, (Accepted 18 March 2017; In press).

Library and documentation

Library and Documentation Centre of CMFRI is one among the best-specialised state of the art libraries in the field of fisheries, aquaculture and marine sciences. Library extended its services to users at HQs and Regional Research Centres, and also to students and researchers from other Institutions, State Fisheries Departments, Universities and Colleges.

Library purchased 50 Scientific books and subscribed 67 National & International Journals with online versions and 975 issues of current periodicals were added to library during the period.

Digital Library

Library digital services can be accessed from the homepage "Library and Publication " hosted in the Institute website. The Library Catalogue, OPAC can be accessed globally for searching the documents available in the library.

Online access made available to e-journals, database Zootaxa and 250 Open access journals on fisheries and marine sciences through the website. Full text of articles can be accessed and downloaded at HQs and Regional/Research Centres.

Access to ICAR-CeRA for e-journals continued to HQs/RCs through Library webpage. More than 3500 e-journals and 1174 e-books on Agriculture and allied subjects are accessible. e-journals on fish and fisheries published by Elsevier, Wiley, Springer, Taylor & Francis are accessible to users at HQs and RCs.

Institutional Repository 'eprints@cmfri'

'eprints@cmfri' is the open access Institutional repository developed for archiving the Intellectual products created by CMFRI. During the period, the repository was added with 797 Institute publications. A total of 11490 Institute publications are available in the open access repository. 'eprints@cmfri' continued to be ranked 1st among ICAR Institutes and 3rd among Indian Repositories. Worldwide usage statistics shows that 182 countries used the repository for more than 85000 sessions during the period and India topped with 58307 sessions.

DSpace@CMFRI

"DSpace@CMFRI" is the digital archive of CMFRI developed for archiving Rare and old publications from the year 1800s available in CMFRI. Six thousand old and rare documents like Memoirs, Catalogues, Reports and Expedition Reports are archived in "DSpace@CMFRI". The documents can be searched by Author, Subject, Keyword and Year of publication. Full text of the documents can be accessed at HQs and RCs of CMFRI.

Current Awareness Service

The digital magazine displays the content pages of latest journals received in library and list of new additions to library.

Online Library Information Service

Release of new publications, activation of online journals and databases as well as other timely information from library were delivered to all scientists in HQs and RCs by email.

Online Document Delivery Service.

Requests for articles received from worldwide users of Institutional repository and ICAR-CeRA users were delivered online.

Newspaper clippings

Two hundred and eighty eight newspaper clippings on the activities and achievements of CMFRI were collected and uploaded in the Institute website. In addition, 796 news clippings on fisheries, aquaculture and other allied subjects published by leading newspapers were collected and compiled as Reference volumes. Links to online versions are made available in the digital library.

User Orientation Service

Orientation classes on the facilities and services of CMFRI library and Institutional Repositories were provided to new users and visitors from various research institutions, universities and colleges.

Library Training Programme

Library and Documentation Centre organised 2 days "National Workshop cum Training on Digital Library Management" for Library Professionals during 26th and 27th November 2016.

National workshop cum training on digital library management

Thirty participants from ICAR Institutes, universities and other Institutions attented. Training imparted to develop and manage Institute Repositories and modernisation of libraries by Eminent library professionals from various universities and Institutes.

Exchange of Publications

Library maintains exchange relationship with various National and International Research Institutes, Universities and other organisations. Mailing lists are maintained for free distribution of Institute publications.

Visitors

2870 visitors comprising students and researchers from various research organisations, universities and colleges availed the library services.

Compilation of publications

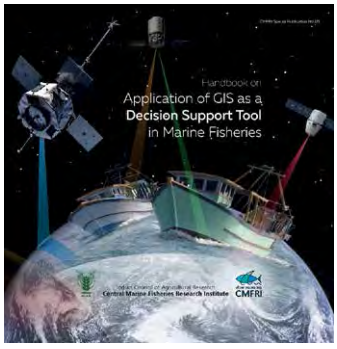
Compiled a brochure on the activities and services of library titled 'CMFRI Library and Documentation Centre' and CMFRI Special publication No. 126, 'Glimpses of Indian Fisheries-A caricature'.

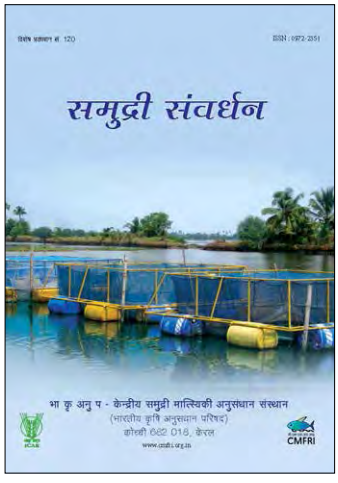
Institute Publications

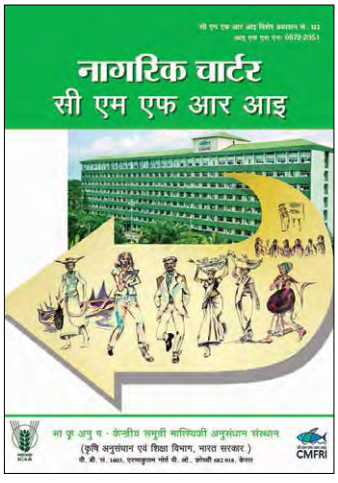
Library is entrusted with arrangements for printing, stock maintenance and sale of Institute publications.

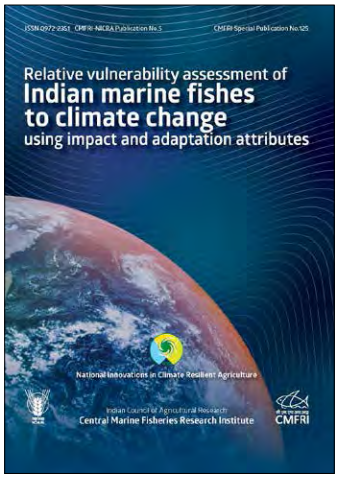
CMFRI Publications released during the period

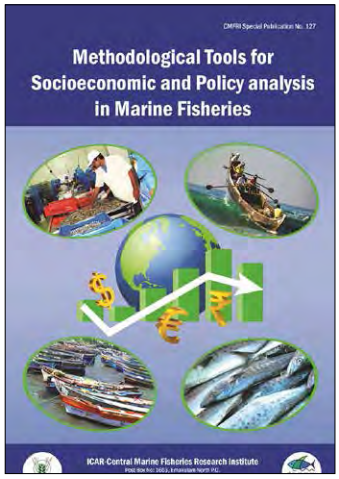
1. Indian Journal of Fisheries Vol. 63 (1-4)
2. CMFRI Annual Report 2015-16
3. Marine Fisheries Information Service No. 225- 228
4. CMFRI Newsletter Cadalmin No. 147-150 (English and Hindi)
5. CMFRI Special Publication No. 120-127
6. Marine Fish Landings in India-2015
7. CMFRI Booklet No.4: 2015-Keralathile matsya bendanavum matsya sampathum
8. CMFRI Booklet No.5: Safety Guidelines for Drivers of CMFRI
9. Marine Fisheries Policy Brief-4: Fishing Using Lights-How should India handle this new development

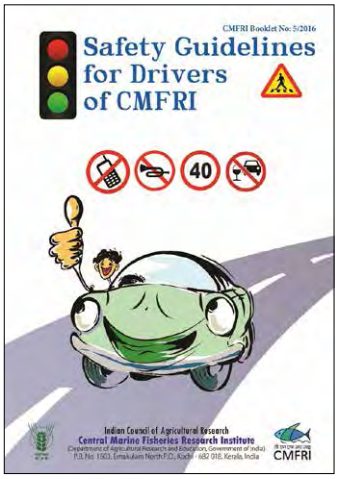


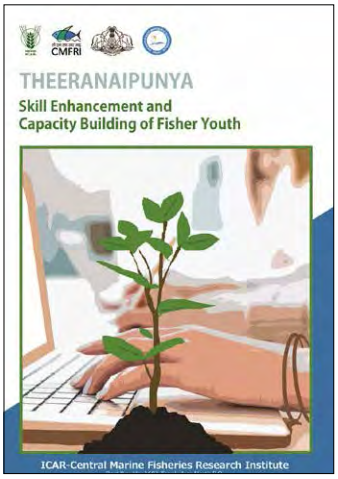












10. CMFRI Marine Fisheries Policy Series No. 6: Non-detriment Findings for the export of shark and ray species
11. ICAR-CMFRI Directory 2016: Desktop Mate
12. Course Manual-National Workshop on Effective Management of E-Resources in Research Libraries
13. Training Manual on Theeranaipunya-A Capacity Building Training Programme Equipping the Fisherwomen Youth for the Future
14. CMFRI Pamphlet No.39/2015: A Glimpse of CMFRI
15. CMFRI Pamphlet No.41/2016: Library and Documentation Centre
16. CMFRI Poster No.19/2016: Oceanic cephalopod fauna of Southeastern Arabian Sea

Budget & expenditure 2016-17

Under Non-Plan & Plan (Figures in lakhs)

Budget Head	Non-Plan		Plan	
	Budget	Expenditure	Budget	Expenditure
Revenue				
Estt. Charges	5076.50	5076.50	0.00	0.00
OTA	1.50	1.06	0.00	0.00
TA	23.00	23.00	120.00	120.00
Other Charges	631.00	631.45	663.00	663.00
Works Repair & Maintenance				
Office Buildings	97.18	92.27	0.00	0.00
Residential Buildings	15.00	18.99	0.00	0.00
Minor work	48.00	48.47	0.00	0.00
Miscellaneous Expenses (including HRD)	28.32	28.32	20.00	20.00
Tribal Sub Plan–General	0.00	0.00	6.00	6.88
Capital				
Equipments	31.00	33.08	195.00	197.19
Information Technology	0.00	0.00	60.65	60.61
Library	2.00	0.00	30.00	26.15
Vessel	0.00	0.00	0.00	0.00
Furniture & Fixtures	5.00	4.92	9.55	12.28
Works				
Land	0.00	0.00	0.00	0.00
Office Buildings	0.00	0.00	43.98	42.95
Resi. Building	0.00	0.00	110.82	110.82
Minor works	0.00	0.00	0.00	0.00
Tribal Sub Plan–Capital	0.00	0.00	6.00	5.11
TOTAL	5958.50	5958.06	1265.00	1264.99

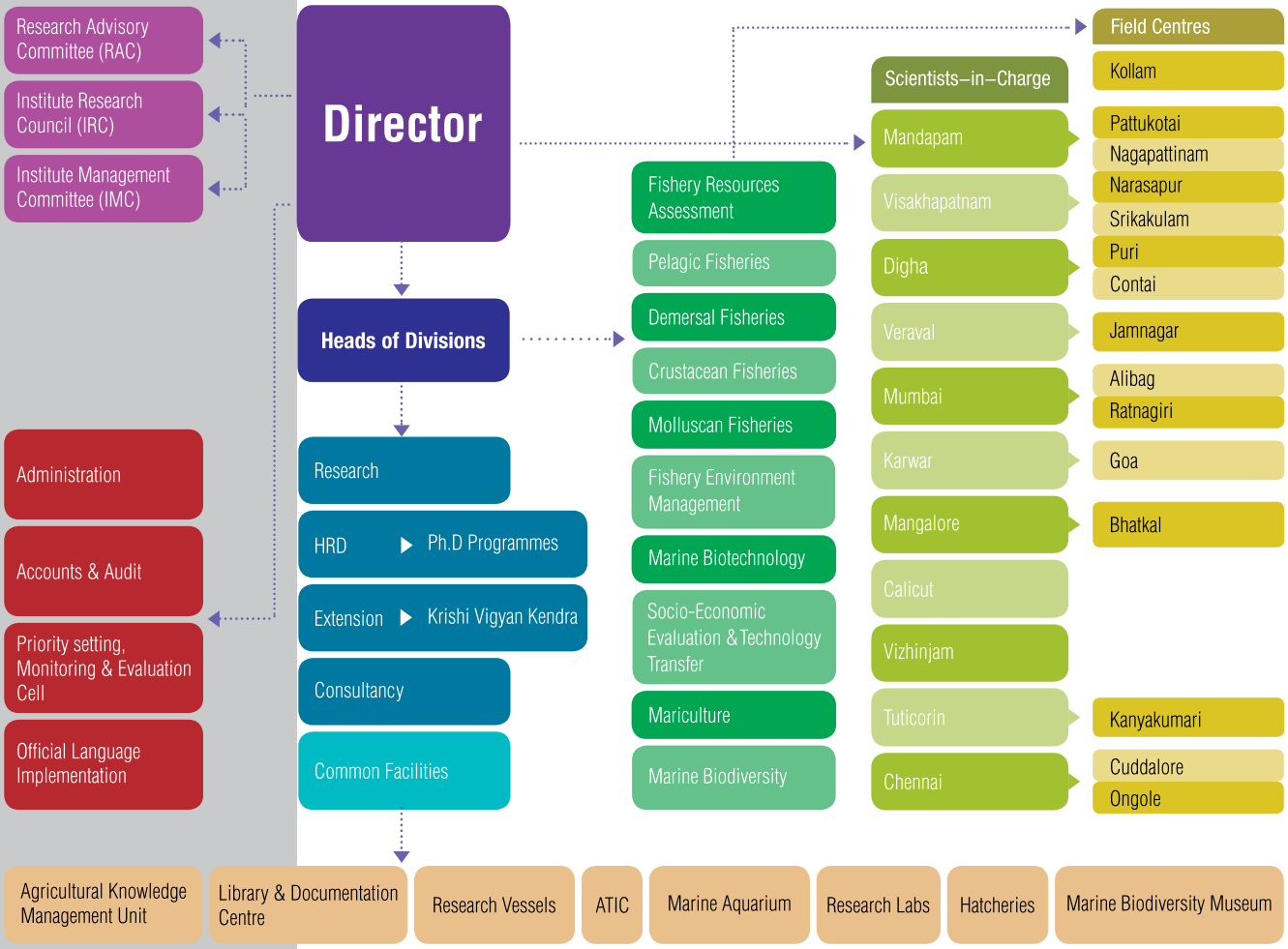
	Budget	Expenditure
Pension	5025.00	4675.00
Loans & Advances	45.00	9.31

Other Projects	Receipts (Including Opening Balance)	Expenditure	Refund
Winter/Summer School	-0.06	0	0.00
Emeritus	11.24	9.57	0.00
AINP M	417.00	417.00	0.00
NICRA	445.37	287.07	157.46
National Fund Schemes	35.10	21.69	0.00
Other Plan Schemes	146.29	123.47	3.34
Deposit Schemes (Externally funded)	563.89	318.59	3.96
KVK, Narakkal	156.27	152.09	0.00
Consultancies	546.60	69.92	0.00

Revenue receipts

Head	Target	Achievement
Income from Sales/services	83.35	49.84
Fee/Subscription	37.09	29.89
Income from Royalty, publication etc.	2.47	6.34
Other Income	0.0	72.6
STD Interest	0.0	85.71
Sale of Asset	0.0	0.09
Recoveries on Loans & Advances	0.0	29.85
CPWD/Grants Refund	0.0	0
TOTAL	122.91	274.32

Organogram


Research Advisory Committee (RAC)
Institute Research Council (IRC)
Institute Management Committee (IMC)
Director
Heads of Divisions
Research
HRD
Ph.D Programmes
Extension
Krishi Vigyan Kendra
Consultancy
Common Facilities
Administration
Accounts & Audit
Priority setting, Monitoring & Evaluation Cell
Official Language Implementation
Fishery Resources Assessment
Pelagic Fisheries
Demersal Fisheries
Crustacean Fisheries
Molluscan Fisheries
Fishery Environment Management
Marine Biotechnology
Socio-Economic Evaluation & Technology Transfer
Mariculture
Marine Biodiversity
Field Centres
Scientists–in–Charge
Mandapam
Visakhapatnam
Digha
Veraval
Mumbai
Karwar
Mangalore
Calicut
Vizhinjam
Tuticorin
Chennai
Kollam
Pattukotai
Nagapattinam
Narasapur
Srikakulam
Puri
Contai
Jamnagar
Alibag
Ratnagiri
Goa
Bhatkal
Kanyakumari
Cuddalore
Ongole
Agricultural Knowledge Management Unit
Library & Documentation Centre
Research Vessels
ATIC
Marine Aquarium
Research Labs
Hatcheries
Marine Biodiversity Museum

Personnel

No	Name of Employee	Designation
SCIENTIFIC STAFF		
KOCHI		
1	Dr. A. Gopalakrishnan	Director & Principal Scientist
2	Dr. K. Sunilkumar Mohamed	Principal Scientist & Head, MFD
3	Dr. (Smt.) V. Kripa	Principal Scientist & Head, FEMD
4	Dr. P.U. Zachariah	Principal Scientist & Head, DFD
5	Dr. R. Narayanakumar	Principal Scientist, & Head, SEETTD
6	Dr. G. Maheswarudu	Principal Scientist & Head, CFD
7	Dr. T.V. Sathianandan	Principal Scientist & Head, FRAD
8	Dr. K.K. Joshi	Principal Scientist & Head, MBD
9	Dr. P. Vijayagopal	Principal Scientist & Head, MBTD
10	Dr. (Smt.) Imelda Joseph	Principal Scientist & Head, MD
11	Dr. P. Kaladharan	Principal Scientist
12	Dr. (Smt.) Molly Varghese	Principal Scientist
13	Dr.P. Jayasankar	Principal Scientist
14	Dr. J. Jayasankar	Principal Scientist / SIC, AKMU
15	Dr. (Smt.) Josileen Jose	Principal Scientist
16	Dr. K. Madhu	Principal Scientist
17	Dr. (Smt.) K.S. Sobhana	Principal Scientist
18	Dr. (Smt.) Shoji Joseph	Principal Scientist
19	Dr. E.M. Abdussamad	Principal Scientist
20	Dr. (Smt.) Rema Madhu	Principal Scientist
21	Dr. (Smt.) D. Prema	Principal Scientist
22	Dr. C. Ramachandran	Principal Scientist
23	Dr. (Smt.) Somy Kuriakose	Principal Scientist
24	Dr. V.P. Vipin Kumar	Principal Scientist
25	Dr. Shyam S. Salim	Principal Scientist
26	Dr. (Smt.) Ganga U	Principal Scientist
27	Dr. (Smt.) Rekha J. Nair	Principal Scientist
28	Dr. (Smt.) S.Lakshmi Pillai	Principal Scientist
29	Dr. S.R. Krupesha Sharma	Principal Scientist
30	Dr. (Smt.) Mini. K.G	Principal Scientist
31	Dr. Boby Ignatius	Principal Scientist & SIC, HRD
32	Dr. (Smt.) N. Aswathy	Senior Scientist
33	Dr. N.K. Sanil	Senior Scientist
34	Dr. (Smt.) Miriam Paul Sreeram	Senior Scientist
35	Dr. T.M. Najmudeen	Senior Scientist
36	Dr. R. Jeyabaskaran	Senior Scientist
37	Dr. Grinson George	Senior Scientist
38	Dr. Kajal Chakraborty	Senior Scientist
39	Dr. (Smt.) Rekhadevi Chakraborty	Senior Scientist
40	Dr. V. Venkatesan	Senior Scientist
41	Dr.(Smt.) Sandhya Sukumaran	Senior Scientist
42	Shri Wilson T. Mathew	Scientist
43	Dr. Pradeep M.A	Scientist
44	Smt. Reshma K.J	Scientist
45	Dr. (Smt.) Vidya R	Scientist
46	Shri Linga Prabhu D	Scientist
47	Shri Sanal Ebenezeer	Scientist
48	Shri Vivekanand Bharti	Scientist
49	Shri Subal Kumar Roul	Scientist
50	Dr. P. Shinoj	Scientist
51	Dr. Rajesh N	Scientist
52	Dr. Sumithra T.G	Scientist
53	Dr. Shelton Padua	Scientist
54	Dr. (Smt.) Livi Wilson	Scientist
55	Dr. Jeena N.S	Scientist
56	Dr. K. Mohammed Koya	Scientist
57	Shri Sreenath K.R	Scientist
KVK		
58	Dr. Shinoj Subramannian	Sr.Scientist & Head
MADRAS		
59	Dr. P. Laxmilatha	Principal Scientist & SIC
60	Dr. Joe K. Kizhakudan	Principal Scientist
61	Dr. (Smt.) Sobha Joe Kizhakudan	Principal Scientist
62	Dr. M. Sivadas	Principal Scientist
63	Dr. (Smt.) P.T. Sarada	Principal Scientist
64	Dr. K. Vijayakumaran	Principal Scientist
65	Dr. (Ms.) A. Margaret Muthu Rathinam	Principal Scientist
66	Dr. Vidya Jayasankar	Senior Scientist
67	Ms. Saima Rehman	Scientist
68	Shri Adan Hussain Gora	Scientist
69	Shri Srinivasa Raghavan V	Scientist
70	Ms. E.M. Chhandaprajnadarsini	Scientist
MANDAPAM		
71	Dr. A.K. Abdul Nazar	Principal Scientist & SIC
72	Dr. Rengarajan Jayakumar	Senior Scientist
73	Shri S. Thirumalaiselvan	Scientist
74	Shri Vinothkumar R	Scientist
75	Shri Sankar M	Scientist
76	Dr. G. Tamilmani	Scientist
77	Dr.M. Sakthivel	Scientist
78	Dr. Johnson B	Scientist
79	Dr. P. Rameshkumar	Scientist
80	Shri Saravanan R	Scientist
81	Dr. Anikuttan K.K	Scientist
82	Shri S. Chandrasekar	Scientist
83	Ms. Remya L	Scientist
84	Shri Rajkumar M	Scientist
85	Dr. Amir Kumar Samal	Scientist
MANGALORE		
86	Dr. Prathibha Rohit	Principal Scientist, SIC & Head, PFD
87	Dr. A.P. Dinesh Babu	Principal Scientist
88	Dr. Sujitha Thomas	Principal Scientist
89	Dr. (Smt.) Geetha Sasikumar	Principal Scientist
90	Dr. K.M. Rajesh	Senior Scientist
91	Dr. (Smt.) Bindu Sulochanan	Senior Scientist
92	Smt. Divya Viswambharan	Scientist
93	Dr. Purushottama G.B	Scientist
MUMBAI		
94	Dr. Veerendra Veer Singh	Principal Scientist & SIC
95	Shri Bhendekar Santosh Nagnath	Scientist
96	Dr. Anulekshmi Chellappan	Scientist
97	Dr. S. Ramkumar	Scientist
98	Shri Ratheesh Kumar R	Scientist

99	Dr. Akhilesh K.V	Scientist
100	Shri Nakhawa Ajay Dayaram	Scientist
PURI		
101	Dr. (Mrs.) Reeta Jayasankar	Principal Scientist
TUTICORIN		
102	Dr. P.P. Manoj Kumar	Principal Scientist & SIC
103	Dr. M.S. Madan	Principal Scientist
104	Dr. I. Jagadis	Principal Scientist
105	Dr. (Smt.) Asha. P.S	Principal Scientist
106	Dr. (Mrs.) C.P. Suja	Senior Scientist
107	Shri Rajan Kumar	Scientist
108	Smt. Shikha Rahandgale	Scientist
109	Shri C Kalidas	Scientist
110	Shri Renjith. L	Scientist
111	Ms. Kavitha M	Scientist
VERAVAL		
112	Dr. Divu Damodaran	Scientist & SIC
113	Shri Abdul Azeez P	Scientist
114	Shri Tarachand Kumawat	Scientist
115	Shri Sukhdhane Kapil Sukhadeo	Scientist
116	Shri Rajesh Kumar Pradhan	Scientist
117	Shri Vinaya Kumar Vase	Scientist
VISAKHAPATNAM		
118	Dr. Shubhadeep Ghosh	Senior Scientist & SIC
119	Dr. S.Sathyanarayana Raju	Principal Scientist
120	Ms. Indira Divipala	Scientist
121	Dr. Ritesh Ranjan	Scientist
122	Dr. (Smt.) Biji Xavier	Scientist
123	Ms. Muktha M.	Scientist
124	Shri Loveson Edward L.	Scientist
125	Shri Pralaya Ranjan Behera	Scientist
126	Dr. Sekar Megarajan	Scientist
127	Ms. Jasmin F	Scientist
VIZHINJAM		
128	Dr. M.K. Anil	Principal Scientist & SIC
129	Dr. P.S. Swathilekshmi	Principal Scientist
130	Dr. B. Santhosh	Principal Scientist
131	Dr. S. Jasmine	Principal Scientist
132	Dr. Smt. K.N. Saleela	Senior Scientist
133	Shri Ambarish P Gop	Scientist
134	Smt. Surya S	Scientist
135	Ms.P. Gomathi	Scientist
CALICUT		
136	Dr. P.K. Asokan	Principal Scientist & SIC
137	Dr. K. Vinod	Principal Scientist
138	Dr. Gulshad Mohamed	Principal Scientist
139	Smt. Ramya Abhijith	Scientist
140	Dr. Mahesh V.	Scientist
141	Shri K.P. Said Koya	Scientist
142	Dr. Suresh Babu P. P	Scientist
143	Ms. Shilta M.T	Scientist
DIGHA		
144	Dr. Gyanranjan Dash	Scientist & SIC
145	Smt. Swathipriyanka Sen Dash	Scientist
KARWAR		
146	Dr. K.K. Philipose	Principal Scientist & SIC
147	Dr. Jayasree Loka	Senior Scientist
148	Dr. T. Senthil Murugan	Senior Scientist
149	Ms. Saloni Shivam	Scientist
150	Shri Kurva Raghu Ramudu	Scientist

TECHNICAL STAFF		
KOCHI		
1	Shri N. Venugopal	Chief Technical Officer
2	Shri N. Viswanathan	ACTO (Civil)
3	Smt. E.K. Uma	ACTO (Hindi Translator)
4	Shri P.S. Anilkumar	ACTO
5	Smt. G. Shylaja	ACTO
6	Dr. V. Mohan	ACTO (Library)
7	Smt. K. Ramani	ACTO
8	Smt. P. Geetha	ACTO (Library)
9	Smt. Jenni. B	Senior Technical Officer
10	Shri Sijo Paul	Senior Technical Officer
11	Smt. K.P. Salini	Senior Technical Officer
12	Shri K.M. Venugopalan	Senior Technical Officer
13	Smt. P.K. Seetha	Senior Technical Officer
14	Dr. M.P. Paulton	Senior Technical Officer (Training)
15	Shri K.N. Pushkaran	Technical Officer
16	Shri V.K. Manu	Technical Officer (Programme Assistant - Computer)
17	Shri P.K. Baby	Technical Officer
18	Shri A.Y. Jacob	Technical Officer
19	Shri K.G. Baby	Technical Officer
20	Smt. Sindhu K. Augustine	Technical Officer
21	Shri A. Padmanabha	Technical Officer (Electrical)
22	Shri K.G. Radhakrishnan Nair	Technical Officer (Motor Driver)
23	Smt. P.M. Geetha	Technical Officer (Museum)
24	Smt. Dipti N.V	Technical Officer (Programme Assistant - Laboratory Technician)
25	Shri N.K. Harshan	Senior Technical Assistant
26	Shri P.S. Alloycious	Senior Technical Assistant
27	Shri K.C. Hezhakiel	Senior Technical Assistant
28	Shri D. Prakasan	Senior Technical Assistant
29	Shri Arun Surendran P.S	Senior Technical Assistant
30	Shri Retheesh. T	Senior Technical Assistant
31	Smt. Lavanya Ratheesh	Senior Technical Assistant
32	Smt. Sajeela.K.A	Tachnical Assistant
33	Shri M.N. Sathyan	Technial Assistant (Motor Driver)
34	Shri Sajikumar K.K	Technical Assistant
35	Shri Retheesh T.B	Technical Assistant
36	Smt. Anusree V. Nair	Technical Assistant
37	Shri Binoy Bhaskaran	Technical Assistant
38	Shri Ragesh N	Technical Assistant
39	Shri Sayooj P	Technical Assistant
40	Shri Aju. K. Raju	Technical Assistant
41	Shri K.M. David	Technical Assistant (Artist)
42	Shri Baby Mathew	Technical Assistant (Motor Driver)
43	Shri C.V. Jayakumar	Technical Assistant (Press & Editorial)
44	Smt. Vandanaa V	Technical Assistant (Hindi Translator)
45	Shri K. Solaman	T-II-3 (Technical Assistant)
46	Shri David Babu	Senior Technician
47	Shri Manjeesh R	Senior Technician (Computer Application)
48	Shri P.R. Abhilash	Senior Technician (Exhibition Assistant)
49	Shri M. Radhakrishnan	Senior Technician
50	Smt. Dhanya G	Senior Technician
51	Shri M. P. Mohandas	Technician
52	Shri V. H. Venu	Technician

53	Smt. J. Sudhadevi	Technician
54	Smt. Shyamala M.P	Technician
55	Shri P.V. Sunil	Technician
56	Shri Shaji A.K	Technician
57	Smt. Sheela P.P	Technician
58	Shri Jestin Joy K.M	Technician
59	Shri Sreekumar K.M	Technician
60	Shri Vijayan M.T	Technician
61	Shri Kishor T.G	Technician
62	Shri Sreesanth L	Technician
63	Shri Sunil K.T.S	Technician
64	Smt. S. Prasannakumari	Technician
QUILON		
65	Shri Paulose Jacob Peter	Technician
KVK		
66	Smt. P. Sreelatha	Chief Technical Officer
67	Shri F. Pushparaj Anjelo	ACTO (SMS- Agricultural Extension)
68	Dr. Karikkathil Smitha Sivadasan	ACTO (SMS- Animal Husbandry)
69	Shri Shoji Joy Edison	ACTO (SMS- Horticulture)
70	Dr. Vikas P.A	Senior Technical Officer (SMS- Fisheries)
MADRAS		
71	Shri S. Mohan	ACTO
72	Shri D. Pugazhendi	ACTO
73	Smt. S. Gomathy	Senior Technical Officer
74	Shri N. Rudhramurthy	Senior Technical Officer
75	Shri P. Jaiganesh	Senior Technical Assistant
76	Shri K.S. Shiak Mohamed Yousuf	Senior Technical Assistant
77	Shri S. Selvanidhi	Technical Assistant
78	Shri M. Ravindran	Senior Technician
79	Shri R. Vasu	Senior Technician
80	Shri R. Sunder	Senior Technician
81	Shri V. Joseph Xavier	Technician
82	Shri Bareen Mohamed	Technician
83	Shri V. Sitaramacharyulu	Technician
84	Shri S. Chandrasekharan	Technician
85	Shri J. Balaji	Technician
KOVALAM		
86	Shri R. Ponniah	Technical Officer (Electrician)
87	Smt. I. Santhosi	Senior Technician
88	Shri Abbas A. Muhammed	Technician
89	Anoob P. Anassery	Technician
CUDDALORE		
90	Shri S. Pradeep	Senior Technician
ONGOLE		
91	Shri G. Sudhakar	Technical Officer
92	Shri S.V. Subba Rao	Senior Technical Assistant
MANDAPAM		
93	Shri P. Chidambaram	ACTO (Library)
94	Shri I. Mendonza Xavier	Senior Technical Officer (Draughtsman)
95	Shri A. Gandhi	Technical Officer
96	Shri S. Sekar V. Rayer	Technical Officer (Skin Diver)
97	Shri D. Anandan	Technical Officer (Deckhand)
98	Shri A. Vairamani	Senior Technical Assistant
99	Shri. P. Villan	Senior Technical Assistant
100	Shri N. Bhoominathan	Senior Technical Assistant
101	Shri M. Asokan	Senior Technical Assistant (Painter-cum-Polisher)
102	Shri G. Hanumantha Rao	Senior Technical Assistant
103	Shri M. Anbarasu	Senior Technical Assistant
104	Shri Ashok Maharshi	Technical Assistant
105	Shri Ravi Kumar Avadhanula	Technical Assistant
106	Smt. Priya K.M	Technical Assistant (Hindi Translator)
107	Shri Vijaya Karthikeyan	Senior Technician (Electrician)
108	Shri M. Palanichamy	Senior Technician (Electrician)
109	Shri K. Shanmughanathan	Senior Technician
110	Shri M. Jayasingh	Techincian
111	Shri S. Murugaboopathy	Technician
112	Shri N. Ramakrishnan	Technician
113	Shri I. Syed Sadiq	Technician
114	Shri V. Muniasamy	Technician
115	Shri B. Kathiresan	Technician
116	Shri K. Muniyasamy	Technician
117	Shri M. Ganesan	Technician
118	Shri M. Thayalan	Technician
119	Shri K. Senthil Kumar	Technician
120	Shri Tinto Thomas	Technician
NAGAPATTINAM		
121	Shri A. Ramesh	Technician
PATTUKOTTAI		
122	Shri A. Kumar	ACTO
123	Shri S.M. Sikkender Batcha	Technician
MANGALORE		
124	Shri C. G. Ulvekar	Senior Technical Assistant
125	Shri V. Lingappa	Senior Technical Assistant
126	Shri M. Chaniappa	Senior Technical Assistant
127	Shri G. D. Nataraja	Senior Technical Assistant
128	Ms. Veena Shettigar	Senior Technical Assistant (Motor Driver)
129	Shri P. Harshakumar	Senior Technical Assistant
130	Shri U. Jeyaram	Senior Technical Assistant
131	Shri Karamathullah Sahib. P	Technician
BHATKAL		
132	Shri Udaya V. Arghekar	Technical Officer
133	Shri Ganesh Bhatkal	Technical Officer
MUMBAI		
134	Shri C.K. Sajeev	ACTO
135	Shri Nilesh Anil Pawar	Senior Technical Officer
136	Shri Thakurdas	Technical Officer
137	Shri Jayadev S. Hotagi	Technical Officer
138	Shri B.B. Chavan	Technical Officer
139	Shri J.D. Sarang	Technical Officer
140	Shri Baban N. Katkar	Technical Officer
141	Shri S.D. Kamble	Technical Officer
142	Shri D.G. Jadhav	Technical Officer
143	Shri Bashir Ahmed Adam Shilodar	Technical Officer
144	Shri Suresh Krishnaro Kamble	Senior Technical Assistant
145	Shri Sashikant R. Yadav	Senior Technical Assistant (Motor Driver)
146	Shri Punam Ashok Khandagle	Senior Technical Assistant
147	Shri Vaibhav Dinkar Mhatre	Technical Assistant
148	Shri Albert Idu K. A	Technical Assistant
149	Shri Umesh Hari Rane	Technical Assistant
150	Shri Prabhakar Sankar Salvi	Senior Technician
151	Shri Bhangare Sunil Ramachandra	Technician
RATNAGIRI		
152	Shri D.D. Sawant	Technical Officer
153	Shri Kishor Raghunath Mainkar	Technical Officer
ALIBAG		
154	Shri M.P. Jadhav	Senior Technician
155	Shri Shrikrishna Pandurang Hotekar	Technician

TUTICORIN		
156	Shri K. Diwakar	ACTO
157	Shri P. Muthukrishnan	Technical Officer (Skin Diver)
158	Shri N. Jesuraj	Technical Officer (Skin Diver)
159	Shri S. Enasteen	Technical Officer (Deckhand)
160	Shri S. Mohamed Sathakathullah	Technical Officer
161	Shri J. Padmanathan	Senior Technical Assistant
162	Shri K. John James	Senior Technician
163	Shri K. Ramaswamy	Senior Technician (Motor Driver)
164	Shri K.P. Kanthan	Technical Assistant
165	Smt. B. Koncies Mary	Technician
166	Shri K. Murugan	Technician
167	Shri S. Willington	Technician
168	Shri N. Ramaswamy	Technician
KANYAKUMARI		
169	Shri P. Rajendran	Senior Technician
VERAVAL		
170	Shri Suresh Kumar Mojjada	ACTO
171	Shri Polara Jamnadas Premji	Technical Officer
172	Shri Ladani Amrutlal Arjunbhai	Technical Officer
173	Shri Vanvi Jayaanthilal Dayabhai	Technical Officer
174	Shri H.M. Bhint	Technical Assistant
175	Ms. Bharadiya Sangita Aravindkumar	Technical Assistant
176	Shri Chudasama Ramji Raja	Senior Technical Assistant
177	Shri Solanki Vipulkumar Mulajibhai	Technician
178	Ms. Gohel Jayshree Khimji	Technician
179	Shri Chudasama Karsan Punja	Technician
180	Shri Bhatt Bhargav Hareshbhai	Technician
JAMNAGAR		
181	Shri Makadia B.V.	Technical Officer
182	Shri Makwana Somapitha	Technician
VISAKHAPATNAM		
183	Dr. Phalguni Pattnaik	ACTO
184	Dr. Biswajit Dash	ACTO
185	Dr. Madhumita Das	ACTO
186	Shri Mamidi Satishkumar	Senior Technical Assistant
187	Shri Narsimhulu Sadhu	Senior Technical Assistant
188	Shri K. Gouri Sankara Rao	Technical Officer (Computer)
189	Shri R.V.D. Prabhakar	Technical Officer
190	Shri T. Nageswara Rao	Technical Officer
191	Shri P. Venkataramana	Technical Officer
192	Shri Balla Vamsi	Technical Assistant
193	Shri Chinni Babu Bathina	Technical Assistant
194	Shri Suresh Kumar Pilli	Technical Assistant
195	Shri K. Lakshminarayana	Technical Assistant (Motor Driver)
196	Shri R. P. Venkatesh	Senior Technician (Fitter)
197	Smt. Sangaru Padmaja Rani	Senior Technician
198	Shri Rachakonda Shivaraju	Technician
199	Shri Durga Suresh Relangi	Technician
200	Shri D. Bhaskara Rao	Technician
201	Shri D. Jaganna	Technician
202	Shri C.H. Moshe	Technician
203	Shri Jishnudev M.A	Technician
204	Shri Panchakarla Nagaraju	Technician
CONTAI		
205	Shri Swapan Kumar Kar	Technical Officer
206	Shri Indranil Mukherjee	Technician
PURI		
207	Shri P.K Harikumar	ACTO
208	Shri M. Kala Mallik	Technician
SRIKAKULAM		
209	Shri Y.V.S. Suryanarayana	Senior Technical Assistant
NARSAPUR		
210	Shri S. Tatabhai	Senior Technician
VIZHINJAM		
211	Shri A. Udayakumar	Senior Technical Officer
212	Shri K.K. Suresh	Senior Technical Officer
213	Shri Jose Kingsly	Senior Technical Officer
214	Shri V.A. Laslie	Senior Technical Officer
215	Shri P. Hillary	Technical Officer (Deckhand)
216	Shri V.P. Benziger	Technical Officer (Deckhand)
217	Shri C. Unnikrishnan	Technical Officer
218	Shri B. Raju	Senior Technical Assistant
219	Shri Midhunraj N.K	Technician
CALICUT		
220	Shri V.A. Kunhikoya	Senior Technical Officer
221	Shri A. Anasukoya	Technical Officer
222	Shri M.M. Bhaskaran	Technical Officer
223	Shri N.P. Ramachandran	Senior Technical Assistant
224	Shri C. Chandran	Senior Technical Assistant
225	Smt. P. Renuka	Technician
226	Shri Ansar Pokkarakath	Technician
227	Ms. Silpa P.G	Technician
228	Shri T. Rajesh Babu	Technician
KANNUR		
229	Shri Shiju P	Senior Technician
KARWAR		
230	Shri Fofandi Mahendra Kumar	Senior Technical Officer
231	Shri Narayan G. Vaidya	Senior Technical Officer
232	Shri S. Satyanarayan V. Pai	Technical Officer
233	Ms. Sonali S. Mhaddolkar	Senior Technical Assistant
234	Shri Kodi Srinivasa Rao	Technical Assistant
235	Dr. Praveen Narayan Dube	Technical Assistant
236	Shri N. Selvakumar	Senior Technician
237	Smt. Pramila Harish Borkar	Technician
GOA		
238	Shri Prakash C. Shetty	Technical Officer

ADMINISTRATIVE STAFF		
KOCHI		
1	Shri C. Muralidharan	Chief Administrative oficer
2	Shri A.V. Joseph	Chief Finance & Accounts Officer
3	Shri H. Ganesha	Finance & Acount officer
4	Shri. Navin Kumar Yadav	Assistant Director (OL)
5	Smt. Meera. K.N	Assistant Administrative Officer
6	Shri P.V. Devassy	Assistant Administrative Officer
7	Smt. C.M. Jenny	Assistant Administrative Officer
8	Smt. V.K. Sobha	Assistant Administrative Officer
9	Smt. Ponnamma Radhakrishnan	Assistant Administrative Officer
10	Smt. P.S. Sumathy	Assistant Administrative Officer
11	Shri K. Ramadasan	Assistant Administrative Officer
12	Smt. M.G. Chandramathy	Assistant Administrative Officer
13	Shri Thomas Joy	Assistant Finance & Accounts Officer
14	Shri P. Krishnakumaran	Assistant Finance & Accounts Officer
15	Smt. M. Safiyabi	Assistant
16	Shri C. Jayakanthan	Assistant
17	Shri P.P. Chandrasekharan Nair	Assistant
18	Shri Rishikesh Aandi	Assistant

19	Smt. N.G. Supriya	Assistant
20	Smt. G. Ambika	Assistant
21	Smt. N.K. Suseela	Assistant
22	Shri K. Baburajan	Assistant
23	Smt. V. Jayalakshmi	Assistant
24	Smt. C.A. Leela	Assistant
25	Smt. Manjusha G. Menon	Assistant
26	Smt. Soumya Surendran	Assistant
27	Smt. Ramya M	Assistant
28	Smt. Molly Lazar	Assistant
29	Shri C.K. Sivadas	Assistant
30	Smt. P.K. Mary	Assistant
31	Smt. Binny Cherian	Assistant
32	Smt. Gouri Hareendran	Assistant
33	Smt. T.C. Chandrika	Assistant
34	Shri K.S. Ajith	Assistant
35	Smt. Sumeena N.K	Assistant
36	Shri D. Augustus Julin Raj	Assistant
37	Shri A.K. Kunjipalu	Assistant
38	Smt. C. Devaki	Assistant
39	Smt. N.R. Lethadevi	Private Secretary
40	Smt. K.V. Sajitha	Private Secretary
41	Smt. P. Vineetha	Private Secretary
42	Shri C.D. Manoharan	Personal Assistant
43	Smt. P.K. Anitha	Personal Assistant
44	Shri K.N. Muraly	Personal Assistant
45	Smt. Bindu Sanjeev	Personal Assistant
46	Smt. K. Smitha	Personal Assistant
47	Smt. Annies Mary Paulose	Upper Division Clerk
48	Shri T.K. Sumesh	Upper Division Clerk
49	Shri K.S. Sunil Raj	Upper Division Clerk
50	Shri Sunil A.T	Upper Division Clerk
51	Shri Joseph Mathew	Upper Division Clerk
52	Smt. Deepa P.N	Upper Division Clerk
53	Smt. Manju Jose	Upper Division Clerk
54	Shri E.A. Roopesh	Upper Division Clerk
55	Smt. Sujatha K.K	Upper Division Clerk
56	Shri A. Yesudhas	Upper Division Clerk
57	Smt. Saritha L	Stenographer Grade III
58	Smt. Dhanya M.B	Stenographer Grade III
59	Smt. Zulekha	Stenographer Grade III
60	Shri S. Sreekumar	Lower Division Clerk
61	Smt. Sreeja N.P	Lower Division Clerk
62	Smt. Sandhya C.K	Lower Division Clerk
63	Shri R. Balakrishnan	Lower Division Clerk
64	Shri S. Maharajan	Lower Division Clerk
KVK		
65	Shri V.C. Subhash	Assistant
66	Smt. Rincy K.R	Stenographer Grade III
MADRAS		
67	Shri Ashish Chobey	Assistant Administrative Officer
68	Smt. S. Leelavathi	Personal Assistant
69	Shri S. Yuvarajan	Assistant
70	Shri W. Sathyavan Neelraj	Upper Division Clerk
71	Smt. S. Anjalidevi	Lower Division Clerk
MANDAPAM		
72	Shri R. Sreenivasan	Assistant Administrative Officer
73	Smt. Febeena P. A	Junior Accounts Officer
74	Smt. N. Gomathi	Private Secretary
75	Smt. M. Rameswari	Assistant
76	Shri B. Balasubramanian alias James	Upper Division Clerk
77	Shri M. Shahul Hameed	Upper Division Clerk
78	Shri M. Saravanan	Lower Division Clerk
79	Smt. M. Valarmathi	Lower Division Clerk
80	Shri R. Saravanan	Lower Division Clerk
MANGALORE		
81	Shri Upendar Kumar	Assistant
82	Shri U. Purandhara Shetty	Assistant
MUMBAI		
83	Smt. Ashlesha Ashok Sawant	Assistant
84	Smt. Priyankakumari	Assistant
85	Shri Vinod P. Bhagayatkar	Assistant
TUTICORIN		
86	Smt. S. Sarada	Assistant
87	Smt. C. Rajeswari	Assistant
88	Smt. T. Mahalakshmi	Assistant
89	Shri J. Vinoth Prabhu Vaz	Assistant
90	Shri A. Dickson Jebaraj	Assistant
91	Shri K. Jerald Raja	Upper Division Clerk
92	Smt. R. Anantharani	Lower Division Clerk
VERAVAL		
93	Shri Chandra Mauli Sharma	Assistant Administrative Officer
94	Shri Vanvi Mansukhlal Madhavji	Assistant
95	Shri Solanki Mukesh Jeshabahi	Lower Division Clerk
96	Shri Rohit A. Chowda	Lower Division Clerk
97	Shri Pandya JatinkumarJethalal	Lower Division Clerk
VISAKHAPATNAM		
98	Smt. G. Hemlata	Assistant Finance & Accounts Officer
99	Smt. D. Madhavi Latha	Assistant
100	Smt. N.C. Saroja	Upper Division Clerk
101	Shri L. Pydi Raju	Upper Division Clerk
VIZHINJAM		
102	Smt. Radhika Krishnan G	Assistant
103	Smt. K. Latha	Assistant
104	Smt. M.P. Kaladevi	Lower Division Clerk
CALICUT		
105	Smt. K.P. Shylaja	Assistant
106	Smt. K. Balamani	Assistant
107	Shri C.P. Umasankar	Lower Division Clerk
108	Shri Ratan P. Naik	Lower Division Clerk
DIGHA		
109	Shri. Santosh Kumar	Assistant

SKILLED SUPPORT STAFF		
KOCHI		
1	Shri S. Mohanan	Skilled Support Staff
3	Shri K.C. Rajappan	Skilled Support Staff
4	Shri V.T. Ravi	Skilled Support Staff
5	Smt. A. Latha	Skilled Support Staff
6	Shri K.G. Jayaprasad	Skilled Support Staff
7	Shri T.K. Antony	Skilled Support Staff
8	Smt. K.T. Prakasini	Skilled Support Staff
9	Smt. P.K. Usha	Skilled Support Staff
10	Shri M.D. Suresh	Skilled Support Staff
11	Smt. S. Usha	Skilled Support Staff
12	Smt. P.K. Sujatha	Skilled Support Staff
13	Shri M.J. Joseph	Skilled Support Staff
14	Smt. Subaida. K.S.	Skilled Support Staff

15	Smt. K.S. Jeeji	Skilled Support Staff
16	Shri Biju George	Skilled Support Staff
17	Shri P.M. Gireesh	Skilled Support Staff
18	Smt. T.R. Kumari	Skilled Support Staff
19	Shri Rajesh P.A.	Skilled Support Staff
20	Shri Rajesh T.K.	Skilled Support Staff
21	Smt. Unniresmi C.U.	Skilled Support Staff
22	Shri Akhil Babu V.	Skilled Support Staff
23	Shri Vishnu Babu T.	Skilled Support Staff
24	Ms. Rinku Joseph	Skilled Support Staff
25	Ms. Deepa R.	Skilled Support Staff
26	Smt. Anju E.T	Skilled Support Staff
27	Smt. Vijayalakshmi V.V.	Skilled Support Staff
28	Shri Kaushik T.R.	Skilled Support Staff
29	Shri Jitheesh T.D	Skilled Support Staff
30	Shri Prashanth P.K	Skilled Support Staff
31	Shri Sibin P. Babu	Skilled Support Staff
32	Shri Ratheesh M	Skilled Support Staff
33	Ms. Sethulakshmi M	Skilled Support Staff
34	Shri Joby P.J	Skilled Support Staff
35	Shri Vishnu B	Skilled Support Staff
36	Ms. Anaswara K.B	Skilled Support Staff
37	Shri Pakkri Muthu S	Skilled Support Staff
38	Smt. Sruthy S	Skilled Support Staff
39	Smt. Jesli Disilva	Skilled Support Staff
40	Shri Akhildev S	Skilled Support Staff
41	Smt. Sreelakshmi S	Skilled Support Staff
42	Smt. Binitha Babu	Skilled Support Staff
43	Smt. Remya E.A	Skilled Support Staff
44	Ms. Soumya K	Skilled Support Staff
45	Shri Ullas Shankar	Skilled Support Staff
46	Ms. Jinimol K.P	Skilled Support Staff
47	Smt. Hima P.H	Skilled Support Staff
48	Smt. Divya K.A	Skilled Support Staff
49	Smt. Aswathy A.S	Skilled Support Staff
50	Shri Eldhose Benny	Skilled Support Staff
51	Shri Thobias P. Antony	Skilled Support Staff
52	Shri Vysakhan P	Skilled Support Staff
53	Shri Sujith R	Skilled Support Staff
54	Smt. Marjana P.M	Skilled Support Staff
55	Smt. Reshma K.S	Skilled Support Staff
56	Shri Abilash Velayudhan	Skilled Support Staff
57	Smt. Keerthy Krishna	Skilled Support Staff
58	Ms. Athira T.G	Skilled Support Staff
59	Smt. Preethy Udayabhanu	Skilled Support Staff
60	Shri Vipinkumar K.K	Skilled Support Staff
61	Shri Jerin V. Jose	Skilled Support Staff
62	Shri Augustine Sipson N.A.	Skilled Support Staff
63	Shri Akhil A.R	Skilled Support Staff
64	Shri Seban John	Skilled Support Staff
65	Smt. Shajala Banu P.M	Skilled Support Staff
66	Smt. Emy K. Baby	Skilled Support Staff
67	Shri M.K. Anilkumar	Skilled Support Staff
68	Jimosh Mohan C. M.	Skilled Support Staff
KVK OF CMFRI		
69	Shri Midhun Kumar P.H	Skilled Support Staff
70	Ms. Nandana P.R	Skilled Support Staff
MADRAS		
71	Shri P. Selvaraj	Skilled Support Staff
72	Smt. R. Kalaiselvi	Skilled Support Staff
73	Shri R. Kumaran	Skilled Support Staff
74	Smt. R. Sarojini	Skilled Support Staff
75	Smt. R. Eswari	Skilled Support Staff
76	Ms. P. Prasannakumari	Skilled Support Staff
77	Shri Midhun Muthayan	Skilled Support Staff
78	Shri T. Balaraman	Skilled Support Staff
79	Shri A. Vinoth	Skilled Support Staff
80	Shri K. Prabhakaran	Skilled Support Staff
81	Shri Raja Sekar R	Skilled Support Staff
82	Shri R.Yuvaraj	Skilled Support Staff
MANDAPAM		
83	Smt. Niranjana A	Skilled Support Staff
84	Shri J. Hameed Sultan	Skilled Support Staff
85	Shri K. Thangavelu	Skilled Support Staff
86	Shri U. Rajendran	Skilled Support Staff
87	Shri K. Jeevanandam	Skilled Support Staff
88	Shri N. Nagamuthu	Skilled Support Staff
89	Smt. Subbulakshmi	Skilled Support Staff
90	Shri M. Saravana Kumar	Skilled Support Staff
91	Shri K. Ganesan	Skilled Support Staff
92	Shri N. Ramamoorthy	Skilled Support Staff
93	Smt. M. Sharaswathi	Skilled Support Staff
94	Shri N. Thirupathi	Skilled Support Staff
95	Shri A. Bose	Skilled Support Staff
96	Shri K. Narayanan	Skilled Support Staff
97	Smt. M. Muthuvelu	Skilled Support Staff
98	Shri T. Jothi Manikandan	Skilled Support Staff
99	Smt. Sabiya Begum	Skilled Support Staff
100	Shri Suresh R	Skilled Support Staff
101	Shri A. Mohammed Kaleem	Skilled Support Staff
102	Smt. M. Afrin Rani	Skilled Support Staff
103	Shri J. Ramachandran	Skilled Support Staff
104	Shri M. Mahalingam	Skilled Support Staff
105	Smt. K. Mathavi	Skilled Support Staff
106	Shri Ravikumar T.T	Skilled Support Staff
107	Shri B. Sravanakumar	Skilled Support Staff
108	Shri R. Rajkumar	Skilled Support Staff
109	Shri Aneesh U	Skilled Support Staff
110	Shri S. Joseph Jegan	Skilled Support Staff
111	Shri V. Anand	Skilled Support Staff
112	Shri V. Jayapradeep	Skilled Support Staff
MANGALORE		
113	Shri Bisun Bhaskar	Skilled Support Staff
114	Shri S. Mahalinga Naik	Skilled Support Staff
115	Smt. Thanujakshi	Skilled Support Staff
116	Shri Shrinath B	Skilled Support Staff
117	Shri Nagaraj Somayya Gond	Skilled Support Staff
118	Ms. Sathyavathi	Skilled Support Staff
119	Ms. Pushpa K	Skilled Support Staff
120	Shri Abdul Hakeem M.M	Skilled Support Staff
121	Shri Dharmaraju L.B	Skilled Support Staff
122	Shri Naveen Raju K.G. Naik	Skilled Support Staff
123	Shri Sujith Kumar	Skilled Support Staff
MUMBAI		
124	Shri K.K. Baikar	Skilled Support Staff
125	Shri D.D. Jangam	Skilled Support Staff
126	Smt. Urmila S. Balmiki	Skilled Support Staff
127	Shri Ashish C.S. Chaturvedi	Skilled Support Staff

128	Shri Vicky Kumar Prajapati	Skilled Support Staff
129	Shri Suresh	Skilled Support Staff
130	Shri Mayank Pratap Singh	Skilled Support Staff
131	Shri Vaibhav Milan Tawde	Skilled Support Staff
132	Shri Vaibhav Jayant Gharat	Skilled Support Staff
133	Shri Asharam Choudhary	Skilled Support Staff
134	Shri Digambar Suresh Kumbhar	Skilled Support Staff
135	Shri M.Saravanakumar	Skilled Support Staff
TUTICORIN		
136	Shri Santhakumar A	Skilled Support Staff
137	Shri S. Alagesan	Skilled Support Staff
138	Shri I. Ravindran	Skilled Support Staff
139	Shri S. Mariappan	Skilled Support Staff
140	Shri M. Soundrapandian	Skilled Support Staff
141	Shri M. Kalimuthu	Skilled Support Staff
142	Shri K. Subramanian	Skilled Support Staff
143	Shri A. Paul Pondi	Skilled Support Staff
144	Smt. A. Usha Rani	Skilled Support Staff
145	Shri C.S. Santhanakumar	Skilled Support Staff
146	Shri K. Chandran	Skilled Support Staff
147	Shri K. Krishnan	Skilled Support Staff
148	Shri K. Anandan	Skilled Support Staff
VERAVAL		
149	Shri Haridas Khimdas Makwana	Skilled Support Staff
150	Shri Ladani Dhirajlal Jamnadas	Skilled Support Staff
151	Smt. Santok A. Bharada	Skilled Support Staff
152	Shri Bhint Mitesh Hiralal	Skilled Support Staff
153	Shri Chorvadi Kamlesh Kalidas	Skilled Support Staff
154	Shri Thakar Milan Rajnikant	Skilled Support Staff
155	Shri Sonara Yogesh Zinabhai	Skilled Support Staff
156	Shri Mushagra Rajit Hasam	Skilled Support Staff
157	Shri Gadhiya Noormamad Alibhai	Skilled Support Staff
VISAKHAPATNAM		
158	Shri D. Lingaraju	Skilled Support Staff
159	Shri Oggu China Venkateswarlu	Skilled Support Staff
160	Shri S. Srinivasulu	Skilled Support Staff
161	Shri R. Pydi Raju	Skilled Support Staff
162	Shri P. Venkatesh	Skilled Support Staff
163	Shri Damodara Rao Padumu	Skilled Support Staff
164	Shri Siram Nookaraju	Skilled Support Staff
165	Shri Seera Harish	Skilled Support Staff
166	Shri Potala Bhaskara Rao	Skilled Support Staff
167	Shri Venkateswarulu Vuyyala	Skilled Support Staff
168	Shri Yenni Prasad Babu	Skilled Support Staff
169	Shri P.Shanmukh Deekshit Kumar	Skilled Support Staff
170	Shri Palli Kalidasu	Skilled Support Staff
VIZHINJAM		
171	Shri B. Babu	Skilled Support Staff
172	Smt. T. Jayakumari	Skilled Support Staff
173	Shri S. Satheesh Kumar	Skilled Support Staff
174	Ms. Sharanya M.P	Skilled Support Staff
175	Ms. Krishna Priya P.M	Skilled Support Staff
176	Shri Jithesh P.T	Skilled Support Staff
177	Smt. Shalini O	Skilled Support Staff
178	Smt. Nisha S.	Skilled Support Staff
179	Shri Anoop K.G	Skilled Support Staff
180	Shri Greever Yoyak V	Skilled Support Staff
181	Smt. Arathy R. Pillai	Skilled Support Staff
CALICUT		
182	Ms. Nishida P	Skilled Support Staff
183	Shri P. Dassan	Skilled Support Staff
184	Shri M.K. Chandran	Skilled Support Staff
185	Shri P. Satheeshkumar	Skilled Support Staff
186	Shri M.P. Devadasan	Skilled Support Staff
187	Shri P.V. Gopalan	Skilled Support Staff
188	Shri P.B. Jeevaraj	Skilled Support Staff
189	Shri V. Rajendran	Skilled Support Staff
190	Smt. Vijisha M	Skilled Support Staff
191	Shri Anirudh K	Skilled Support Staff
KARWAR		
192	Shri Subhash K. Naik	Skilled Support Staff
193	Shri Ramakant Shankar Harikantra	Skilled Support Staff
194	Smt. Nandini Mayekar	Skilled Support Staff
195	Shri T.P. Renilkumar	Skilled Support Staff
196	Ms. Pooja Mahabaleswar Gajinkar	Skilled Support Staff
197	Shri Suraj Surendra Kalgutkar	Skilled Support Staff
198	Shri Vineeth T	Skilled Support Staff
199	Ms. Veena Ulhas Kamble	Skilled Support Staff
200	Shri Ravichandra Angadi	Skilled Support Staff
201	Shri. Manoj Rajendra Hulswar	Skilled Support Staff
202	Smt.Vijayalakshmi Y Gamanagatti	Skilled Support Staff

CANTEEN STAFF		
KOCHI		
1	Shri M.V. Devassykutty	Canteen Attendant
2	Shri P.K. Purushan	Canteen Attendant

Research projects

In-house

Sl. No	Project Code	Title of the Project	PI of the project & Division	Co-PIs	Duration	Total Cost (₹Lakhs)
1.	FISHCMFRISIL 201200100001	GIS based management advisory support information system for the marine fisheries sector	Dr. T. V. Sathianandan FRAD	Dr. J. Jayasankar Dr. Somy Kuriakose Dr. K.G. Mini Shri Wilson T Mathew Dr. Grinson George Shri Vinaya kumar Vase	2012 - 2017	2822
2.	FISHCMFRISIL 201200200002	Remote sensing assisted oceanologic biodynamic forecasting paradigm for Indian marine resources	Dr. J. Jayasankar FRAD	Dr. T. V. Sathianandan Dr. R. Narayanakumar Dr. Somy Kuriakose Dr. K.G. Mini Shri Wilson T Mathew Dr. Prathibha Rohit Shri K.R. Sreenath Dr. Gyanaranjan Dash Dr. Anulekshmi Chellappan Shri L. Ranjith Dr. B.Johnson Kum. Indira Divipala Shri N.Rajendra Naik Dr. Grinson George Dr. Reeta Jayasankar Dr. G.B. Purushottama Dr. Bindu Sulochanan Dr. P.U. Zacharia Dr. P. Hemasankari Dr. Loveson Edward Shri Vinaya kumar Vase Dr. D. Prema Dr. I. Rajendran Dr. Amir Kumar Samal	2012 - 2017	454.68
3.	FISHCMFRISIL 201200300003	Development of Fishery Management Plans for Sustaining Marine Fisheries of Kerala and Lakshadweep	Dr. Rekha J. Nair DFD	Dr. P. U. Zacharia Dr. T. M. Najmudeen Dr. V. Venkatesan Dr. G. Maheswarudu Dr. Josileen Jose Dr. S. Lakshmi Pillai Dr. Rekha Devi Chakraborty Dr. E. M. Abdusammad Dr. U. Ganga Shri K. P. Said Koya Dr. P. K. Asokan Dr. M.K. Anil Dr. K.N. Saleela Dr. B. Santhosh Dr. Somy Kuriakose Dr. R. Vidya Shri Subal Kumar Raul	2012 - 2017	955.33
4.	FISHCMFRISIL 201200400004	Development of Fishery Management Plans for Sustaining Marine Fisheries of Gujarat	Shri K. Mohammed Koya PFD	Smt. Swatipriyanka Sen Dr. Gyanaranjan Dash Shri Vinaya kumar Vase Shri Rajesh Kumar Pradhan	2012 - 2017	711.28

5.	FISHCMFRISIL 201200500005	Assessment of Elasmobranch Resources in the Indian Seas	Dr. Shoba Joe Kizhakudan DFD	Dr. P. U. Zacharia Dr. K. S. Sobhana Dr. T. M. Najmudeen Dr. Rekha. J. Nair Dr. P.P. Manojkumar Dr. Sujitha Thomas Smt. M. Muktha Dr. G. B. Purushottama Smt. Swatipriyanka Sen Dr. B. Santhosh Shri R. Saravanan Shri L.Ranjith Dr. K. V. Akhilesh Smt. L. Remya	2012 - 2017	492.7
6.	FISHCMFRISIL 201200600006	Development of fishery management plans for sustaining marine fisheries of Karnataka and Goa	Dr. Prathibha Rohit PFD	Dr. A. P. Dineshbabu Dr. Sujitha Thomas Dr. K.M. Rajesh Dr. Geetha Sasikumar Dr. P. S. Swathilekshmi Dr. Bindu Sulochanan Dr. K.G. Mini	2012 - 2017	447.5
7.	FISHCMFRISIL 201200700007	Development of strategies to sustain the stock and fishery of large pelagics in Indian waters	Dr. E.M. Abdussamad PFD	Shri K.P. Said Koya Shri K. Mohammed Koya Smt. Anulekshmi Chellappan Dr. Prathibha Rohit Dr. K.M. Rajesh Dr. U. Ganga Dr. S. Jasmine Dr. M. Sivadas Dr. A. Margaret Muthu Rathinam Dr. Shubhadeep Ghosh Dr. K.G. Mini Shri Nakhawa Ajay Dayaram Shri Subal Kumar Roul Smt. S. Soorya	2012 - 2017	686.5
8.	FISHCMFRISIL 201200800008	Development of Fishery Management Plans for sustaining Marine Fisheries of Tamil Nadu and Puducherry	Dr. M. Sivadas PFD	Dr. P. P. Manojkumar Dr. I. Jagdis Dr. P. T. Sarada Dr. Shobha Joe Kizhakkudan Dr. Margaret Muthu Rathinam Smt. Indira Divipala (up to Oct 2016) Dr. K. N. Saleela Dr. Grinson George Shri R. Saravanan Dr. M. Rajkumar Smt. S. Surya Smt. M. Kavitha Smt. P. Hemasankari	2012 - 2017	450.638
9.	FISHCMFRISIL 201200900009	GIS based resource mapping of distribution and abundance of finfishes and shellfishes off Indian coast for suggesting operational based strategies for fisheries management	Dr. A.P. Dineshbabu CFD	Shri K. Mohammed Koya Dr. Gyanranjan Dash Smt. Swatipriyanka Sen Dr. Anulekshmi Chellappan Dr. Prathibha Rohit Dr. Sujitha Thomas Dr. K. M. Rajesh Dr. Senthil Murugan Dr. P. P. Manojkumar Dr. Josileen Jose Dr. S. Lakshmi Pillai Dr. Rekha Devi Chakraborty Dr. T.M. Najmudeen Dr. K.N. Saleela Dr. P. T. Sarada Dr. M. Sivadas Dr. Shobha Joe Kizhakkudan Smt. Indira Divipala Dr. Shubhadeep Ghosh Smt. M. Muktha Shri N. Rajendra Naik Shri R. Ratheesh Kumar	2012 - 2017	795.88

10.	FISHCMFRISIL 201201000010	Development of Fishery Management Plans for Sustaining Marine Fisheries of Maharashtra	Dr. V. V. Singh FEMD	Dr. Anulekshmi Chellappan Dr. G. B. Purushottama Dr. S. Ramkumar Shri Nakhawa Ajay Dayaram Dr. K. V. Akhilesh Shri. R. Ratheesh Kumar	2012 - 2017	1135.66
11.	FISHCMFRISIL 201201100011	Development of Fishery Management Plans (FMPs) for Sustaining Marine Fisheries of Andhra Pradesh	Smt. M. Muktha DFD	Dr. Shubhadeep Ghosh Shri Loveson Edward Shri N. Rajendra Naik (up to Oct 2016) Shri. Wilson T. Mathew Smt. F. Jasmine Smt. Indira Divipala (from Oct 2016 onwards) Dr. S. S. Raju	2012 - 2017	589.2
12.	FISHCMFRISIL 201201200012	Development of Fishery Management Plans (FMPs) for the bivalve fisheries of India.	Dr. Geetha Sasikumar MFD	Dr. K. S. Mohamed Dr. I. Jagdis Dr. V. Venkatesan Dr. P. K. Asokan Dr. M.K. Anil Dr. R. Vidya Smt. F. Jasmie Smt. M. Kavitha Shri. Wilson T. Mathew	2012 - 2017	515.2
13.	FISHCMFRISIL 201201300013	Evaluation of ornamental gastropod fisheries in India and assessment of shell craft industry	Dr. I. Jagadis MFD	Dr. V. Venkatesan Dr. Shyam S. Salim Shri C. Kalidas Smt. M. Kavitha Smt. F. Jasmine Smt. E. M. Chhandaprajnadarsini Shri. Rajesh Kumar Pradhan	2012-2017	166.96
14.	FISHCMFRISIL 201201400014	Sustainable molluscan mariculture practices	Dr. P. K. Asokan MFD	Dr. K. S. Mohamed Dr. I. Jagdis Dr. Geetha Sasikumar Dr. M. K. Anil Dr. V. Kripa Dr. P. Kaladharan Dr. V.P. Vipinkumar Dr. R. Vidya Smt. M. Kavitha Dr. M. Rajkumar Smt. S. Surya	2012 - 2017	408.3
15.	FISHCMFRISIL 201201500015	Bioinventorying and biodiversity valuation of marine organisms in selected marine ecosystems along the Indian coast	Dr. K. K. Joshi MBD	Dr. P. Laxmilatha Dr. Molly Varghese Dr. S. Jasmine Dr. R. Narayanakumar Dr. K. R. Sreenath Shri R. Saravanan Dr. L. Renjith Shri Pralaya Ranjan Behera Dr. S. Ramkumar Dr. K. Vinod Smt. Divya Viswambaran Dr. Miriam Paul Sreeram	2012 - 2017	460
16.	FISHCMFRISIL 201201600016	Investigations on vulnerable coral reef ecosystems of Indian waters with special emphasis on formulation of management measures for conservation	Dr. S. Jasmine MBD	Dr. K. Vinod Dr. Molly Varghese Dr. K. S. Sobhana Dr. K. R. Sreenath Shri R. Saravanan Dr. L. Ranjith Shri Pralaya Ranjan Behera Dr. S. Ramkumar Dr. P. Laxmilatha Dr. Miriam Paul Sreeram Smt. Divya Viswambaran	2012 - 2017	645.7

17.	FISHCMFRISIL 201201800018	Ecosystem process of critical marine habitats and development of protocols for restoration	Dr. V. Kripa FEMD	Dr. D. Prema Dr. R. Jayabaskaran Dr. P. Kaladharan Dr. Bindhu Sulochanan Dr. V. V. Singh Dr. P. S. Asha Smt. P. Hemasankari Shri Loveson Edward Dr. Geetha Sasikumar Dr. K. Vijayakumaran Dr. Reeta Jayasankar Shri Sukhdhane Kapil Sukhdadeo Smt. Ramya Abhijith Shri Thirumalai Selvan Dr. Shelton Padua	2012 - 2017	1095
18.	FISHCMFRISIL 201201900019	Pollution and litter in the coastal and marine ecosystem and their impact	Dr. P. Kaladharan FEMD	Dr. V. Kripa Dr. D. Prema Dr. R. Jayabaskaran Dr. Bindhu Sulochanan Dr. V. V. Singh Dr. P. S. Asha Smt. P. Hemasankari Shri Loveson Edward Dr. K. Vijayakumaran Dr. Reeta Jayasankar Shri Sukhdhane Kapil Sukhdadeo Smt. Ramya Abhijith Shri. Thirumalai Selvan Dr Shelton Padua	2012 - 2017	1337.7
19.	FISHCMFRISIL 201202000020	Economics of marine fisheries and sustainable management: Policy Issues and Interventions	Dr. R. Narayanakumar SEETTD	Dr. M. S. Madan Dr. C. Ramachandran Dr. Shyam. S. Salim Dr. P. S. Swathilekshmi Dr. N. Aswathy Dr. R. Geetha Dr. B. Johnson Dr. P. Shinoj Dr. S. S. Raju	2012 - 2017	237
20.	FISHCMFRISIL 201202200022	Capacity development for Ecosystem Based Responsible Fisheries Management in India - A co-learning action research	Dr. C. Ramachandran SEETTD	Dr. V.P Vipinkumar Dr. P. S. Swathilekshmi Dr. B. Johnson Dr. P. Shinoj	2012 - 2017	103.75
21.	FISHCMFRISIL 201202300023	Supply chain management of marine fisheries sector In India	Dr. Shyam S. Salim SEETTD	Dr. R. Narayanakumar Dr. M. S. Madan Dr. T. V. Sathianandan Dr. V.P. Vipinkumar Dr. N. Aswathy Dr. R. Geetha Dr. B. Johnson	2012 - 2017	239.72
22.	FISHCMFRISIL 201202400024	Development and standardisation of seed production technologies for selected high value finfishes and shellfishes	Dr. A. K. Abdul Nazar MD	Dr. R. Jayakumar Dr. G. Tamilmani Dr. M. Sakthivel Dr. P. Rameshkumar Shri C. Kalidas Dr. K. Madhu Dr. Rema Madhu Dr. Boby Ignatius Dr. Imelda Joseph Dr. Shoji Joseph Dr. Ritesh Ranjan Smt. Biji Xavier Dr. B. Santhosh Dr. K. K. Philipose Dr. Jayashree Loka Dr. T. Senthil Murugan	2012 - 2017	3621.85

				Dr. D. Divu Dr. Joe K. Kizhakudan Dr. Gulshad Mohammed Shri Loveson Edward Shri Pralaya Ranjan Behera Dr. Amir Kumar Samal Dr. Sekar Megarajan Dr. P. P. Sureshbabu Dr. K.K. Anikuttan Smt. M. T. Shilta Shri S. Chandrasekar		
23.	FISHCMFRISIL 201202500025	Innovations in sea cage farming and coastal mariculture	Dr. K. K. Philipose MD	Dr. Jayasree Loka Dr. Senthil Murugan Dr. Krupesha Sharma Dr. D. Divu Dr. A.K. Abdul Nazar Dr. R. Jayakumar Dr. G. Tamilmani Dr. P. Ramesh Kumar Dr. M. Saktivel Shri C. Kalidas Dr. B. Johnson Dr. Ritesh Ranjan Smt. Biji Xavier Dr. Rema Madhu Dr. K. Madhu Dr. Boby Ignatius Dr. Imelda Joseph Dr. Shoji Joseph Dr. N. Aswathy Dr. A.P Dinesh Babu Dr. Sujitha Thomas Dr. Joe K. Kizhakudan Shri K. Mohammed Koya Dr. Gulshad Mohammed Dr. P. P. Manoj Kumar Dr. Reeta Jayasankar Dr. B. Santhosh Dr. Amir Kumar Samal Dr. Sekar Megarajan Dr. N. Rajesh Dr. K. K. Anikuttan Shri M. Shankar Shri Vinay Kumar Vase Dr. P. P. Suresh Babu Smt. M. T. Shilta Dr. P. Shinoj	2012 - 2017	2304.4
24.	FISHCMFRISIL 201202600026	Health management in selected finfish and shellfish for mariculture and aquariculture & bioprospecting from marine resources	Dr. N. K. Sanil MBTD	Dr. P. Vijayagopal Dr. Kajal Chakraborty Dr. M. A. Pradeep Dr. Sandhya Sukumaran Dr. P. K. Asokan Dr. I. Rajendran Dr. Krupesha Sharma Dr. Jayasree Loka Dr. M. K. Anil Dr. Joe K. Kizhakudan Dr. Vidya Jayasankar Dr. V. Srinivasa Raghavan Dr. Rithesh Ranjan Dr. P. Ramesh Kumar Ms. Saloni Shivam Smt. K. J. Reshma Dr. T. G. Sumithra	2012 - 2017	1026
25.	FISHCMFRISIL 201202700027	Aquatic feed biotechnology for mariculture and aquariculture	Dr. P. Vijayagopal MBTD	Dr. I. Rajendran Dr. M. A. Pradeep Dr. Joe K. Kizhakudan Dr. Boby Ignatius Dr. Krupesha Sharma Dr. Vidya Jayasankar Dr. Kajal Chakraborty Shri C. Kalidas Mr. D. Linga Prabu Mr. S. Chandrasekar Mr. Sanal Ebenezer Dr. C. P. Suja	2012 - 2017	1356

26.	FISHCMFRISIL 201202800028	Genetics, genomics and biotechnological applications in mariculture and fishery resources management	Dr. A. Gopalakrishnan	Dr. Sandhya Sukumaran Dr. V. Srinivasa Raghavan Dr. M. A. Pradeep Dr. P. Kaladharan Dr. C. P. Suja Dr. N. S. Jeena	2012 - 2017	394.5
27.	FISHCMFRISIL 201202900029	Development of tissue culture technology for *in vitro* production of pearls from the blacklip pearl oyster *Pinctada margaritifera* and refinement of *in vitro* pearl formation in *Pinctada fucata*	Dr. C. P. Suja MBTD	Dr. Vidya Jayasankar Dr. V. Srinivasa Raghavan Smt. Indira Divipala	2012 - 2017	351
28.	FISHCMFRISIL 201203100031	Derivation and characterization of embryonic (ES) and induced pluripotent (iPS) stem cell lines from selected marine fish species aimed at mariculture/ conservation	Dr. K. S. Sobhana MBD	Dr. K. Madhu Dr. Rema Madhu Shri C. Kalidas Dr. M. Sakthivel	2012 - 2017	144
29.	FISHCMFRISIL 201203200032	Trawl fishery of the Northeast coast of India: An appraisal	Dr. Shubhadeep Ghosh PFD	Dr. Reeta Jayasankar Smt. M. Muktha Shri Pralaya Ranjan Behera Shri N. Rajendra Naik	2012 - 2017	101.7
30.	FISHCMFRISIL 201400100033	Assessment and valuation of Coral reef Island ecosystem	Dr. P. Laxmilatha MBD	Dr. R. Narayanakumar Dr. S. Jasmine Dr. K. R. Sreenath Shri R. Saravanan Shri Pralaya Ranjan Behera Dr. L. Ranjith Dr. S. Ramkumar Smt. Divya Viswambharan	2014- 2017	169
31.	FISHCMFRISIL 201400200034	Resource assessment, exploitation and utilization of marine algae from Indian Coasts	Dr. P. Kaladharan FEMD	Dr. Reeta Jayasankar Dr. V. V. Singh Dr. B. Johnson Shri Loveson Edward	2014-2017	121.2
32.	FISHCMFRISIL 201400300035	Gender Mainstreaming and Impact of Self Help Groups in Marine Fisheries Sector	Dr. V. P. Vipinkumar SEETTD	Dr. R. Narayanakumar Dr. C. Ramachandran Dr. P. S. Swathilekshmi Dr. Shyam. S. Salim Dr. N. Aswathy Dr. B. Johnson Dr. Shinoj Subrammannian Dr. Reeta Jayasankar	2014- 2017	70
33.	FISHCMFRISIL 201500100036	Critical assessment of reproductive strategies and growth patterns of selected high value finfishes for Mariculture	Dr. Imelda Joseph MD	Dr. K. Madhu Dr. Boby Ignatius Dr. Jayasree Loka Dr. A. K. Abdul Nazar Dr. G. Tamilmani Dr. K. K. Anikuttan Smt. M. Muktha Dr. Joe K. Kizhakudan Dr. B. Santhosh	2015-2017	104 .00

Research Projects

Externally Funded

Sl. No.	Title of the project	Principal Investigator	Funding Agency	Duration	Total Cost (₹ in Lakhs)
1.	Commercial viability of black pearl production in the A&N Islands and Conservation mariculture of ETP gastropods	Dr. K.S. Mohammed	MoES- CMLRE	2012-2017	254.43
2.	Flow of matter through trophic levels and biogeochemical cycles in marine and estuarine ecosystems	Dr. Sujitha Thomas	MoES-CMLRE	2010-2018	89.00
3.	National Initiative on Climate Resilient Agriculture (NICRA)	Dr. P.U. Zacharia	DARE- ICAR	2012-2017	249.00
4.	Seed production of marine food fishes and ornamental fishes	Dr. K. Madhu	ICAR- Revolving Fund	2012-2017	2570.37
5.	Satellite telemetry studies for understanding environmental preferences and migratory patterns of yellowfin tuna, *Thunnus albacares* in the Indian Ocean	Dr. Prathibha Rohit	MoES- INCOIS	2012-2017	63.00
6.	Towards developing models for prediction of recruitment success in major Indian marine fish stocks	Dr. V. Kripa	MoES- CMLRE	2012-2017	95.00
7.	Assessment of deep-sea fishery resources of the continental slope of the Indian EEZ	Dr. U. Ganga	MoES-CMLRE	2012-2017	95.76
8.	Resources assessment and barcoding of Elasmobranchs	Dr. P.U. Zacharia	MoES-CMLRE	2012-2017	81.00
9.	Eco-biological investigations on major pelagic fishes and eco biological modelling of the epipelagic habitat off Kerala and Lakshadweep	Dr. V. Kripa	MoES-INCOIS	2012-2017	88.26
10.	Stock characterisation, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*)	Dr. Ritesh Ranjan	ICAR-NFBSFARA	2012-2017	158.91
11.	Drugs from the sea -development of antimicrobial, anti-inflammatory and anticancer agents from the marine organisms and micro-organisms	Dr. Kajal Chakraborty	MoES-CMLRE	2013-2017	50.00
12.	Global learning for local solution: Reducing vulnerability of marine dependent coastal communities	Dr. A. Gopalakrishnan	Belmont Forum through MoES	2013-2016	165.75
13.	National surveillance programme for aquatic animal diseases	Shri N.K. Sanil	NFDB	2013-2018	122.01
14.	Outreach activity on fish genetic stocks	Dr. A. Gopalakrishnan	ICAR Outreach	2012-2017	100.00
15.	Nutrient profiling and evaluation of fish as a dietary component	Dr. Kajal Chakraborty	ICAR-Outreach	2012-2018	100.00
16.	ICAR Outreach activity on fish feeds	Dr. P. Vijayagopal	ICAR Outreach	2012-2017	100.00
17.	Characterisation of poly saccharides and phenolics from marine macroalgae as defense metabolites against oxidative stress and inflammation	Dr. Kajal Chakraborty	DST	2013-2016	36.00
18.	Polyunsaturated fatty acid enriched formulations from locally available low-value fish and fishery by-catch for use as nutraceuticals and aquafeed supplements	Dr. Kajal Chakraborty	DST	2013-2016	32.00
19.	ICAR Consortium Research Platform (CRP) on Health Food: Development of nutraceuticals supplements from marine molluscs, macro-algae and shrimps	Dr. Kajal Chakraborty	ICAR	2016-2020	294.00
20.	High value compounds/ Phytochemicals	Dr. Kajal Chakraborty	ICAR	2012-2017	294.00

21.	Molecular approach to diet analysis in selected commercially important tunas	Dr. Sandhya Sukumaran	DST	2014-2017	17.00
22.	Assessment of extent of community dependence on the coastal ecologically sensitive areas in Vembanadu lake	Dr. Shyam.S.Salim	NCSCM	2015-2016	5.50
23.	Derivation and characterisation of embryonic stem (ES) cell lines from the marine ornamental maroon clown fish *Premnas biaculeatus* and induced pluripotent stem (iPS) cell lines from the humpback grouper *Chromileptes altivelis*	Dr. K.S. Sobhana	DBT	2015-2018	64.30
24.	Mapping of deep-sea and hypersaline microbiota and characterisation using meta-omics approaches for bio prospecting of novel genes	Dr. M. A. Pradeep	ICAR AMAAS –NBAIM	2014-2017	32.22
25.	Performance appraisal of *Theeramythiri* initiatives in Kerala – A socio economic impact assessment	Dr. Shyam S Salim	SAF-DoF-GoK	2015 – 2016	12.00
26.	Remote sensing & GIS for ecosystem based marine living resources management	Dr. A.P. Dinesh Babu	SAC	2015- 2018	20.00
27.	Molecular taxonomy and phylogeny of Cones (Cone snails) and Strombs (Mollusca, Gastropoda) of the Indian coast	Dr. P. Laxmilatha	DBT	2015-2018	58.53
28.	Scaling up of bivalve farming at Sindhudurg district in the state of Maharashtra	Dr. P.K. Asokan	UNDP-GEF	2015-2016	13.00
29.	Modelling biogeochemical cycles in coastal oceans	Dr. Vinaya Kumar Vase	SAC	2015-2018	19.14
30.	Genetic tagging of spawning populations of Indian oil sardine, *Sardinella longiceps* along south west coast of India using microsatellite markers	Dr. Sandhya Sukumaran	KSCSTE	2015-2017	24.50
31.	Utilisation of marine Bio-resources, market linkages and access benefit sharing in marine sector of Dakshina Kannada, Karnataka	Dr. Rajesh K.M.	KBB (Karnataka Biodiversity Board)	2016–2017	5.00
32.	Advanced phytoplankton cultivation method for hatchery feed with special emphasis on mussel seed production	Dr. M.K. Anil	KSCSTE	2016-2017	10.00
33.	Impact, vulnerability and adaptation strategies for marine fisheries of India	Dr. A. Gopalakrishnan	NATCOM	2016-2018	25.30
34.	DBT sponsored national training programme on molecular biology and biotechnology for fisheries professionals	Dr. P. Vijayagopal	DBT	2015-2018	48.25
35.	Consortium Research Platform (CRP) on Vaccines and Diagnostics	Dr. N.K. Sanil	ICAR	2012-2017	363.16
36.	AINP on Fish Health	Dr. N.K. Sanil	ICAR	2017-2020	51.00
37.	AINP on Mariculture	Dr. K.K. Philipose	ICAR	2017-2020	1025.00

Research Projects

Consultancy

No.	Client	Project title	PI	Status	Amount (₹lakhs)
1006270	The Project Director International Fund for Agricultural Development (IFAD) assisted Post Tsunami Sustainable Livelihood Programme, (PTSLP) Tamil Nadu Corporation for Development of Women Ltd., 100 Anna Salai Road, Guindy, Chennai	Consultancy on artificial reefs in inshore waters of four districts of Tamil Nadu	Shoba Joe Kizhakkudan	Part II in progress	19.90
1006919	Commissioner of Fisheries, Dept. of Fisheries, Govt. of Tamil Nadu	Installation of artificial reefs in inshore waters of two villages in Kancheepuram District of Tamil Nadu	Shoba Joe Kizhakkudan	Part II in progress	30.00
1006718	Director of Fisheries, Dept. of Fisheries, Tamil Nadu	Installation of artificial reefs in the inshore waters of seventeen villages along Tamil Nadu coast	Laxmilatha P	In progress	260.80
1005842	P. Koteswara Rao, Joint Director of Fisheries, Visakhapatnam, Andhra Pradesh	Installation of artificial reef at a selected site off Visakhapatnam, Andhra Pradesh	Loveson Edward	In progress	30.32
1006299	Program Director, Management of Coastal and marine protected areas, Biodiversity program office, GIZ, New Delhi	Study on enhancing the effectiveness of conservation potential of marine mammals in Indian seas	P. R. Jeyabaskaran	In progress	15.41
1006469	The Project Director, Tamil Nadu Corporation for Development of Women Ltd., 100 Anna Salai Road, Guindy, Chennai	Consultancy on livelihood enhancement of fishermen through deployment of AR in inshore waters along the six districts of TN	Joe Kizhakudan	In progress	92.98
1006655	M/s JSW Infrastructure Limited, JSW Centre, Bandra Kurla Complex, Bandra (East), Mumbai	Assessment of impact on fish production due to development of all weather captive jetty at Nandgaon, Maharashtra	V. V. Singh	In progress	68.59
1007441	The Gujarat Livelihood Promotion Company Ltd., Block-18, 3rd Floor, Sector – 11, Udhyog Bhavan, Gandhinagar – 382 011 Gujarat.	Feasibility study for commercial scale seaweed cultivation in Gujarat under project Sagar Lakshmi	Mohamed Koya K	In progress	10.00
1007751	Commissioner of Fisheries, Commissionerate of Fisheries, Third Floor, Block No.10, Jivraj Mehta Bhavan, Gandhi Nagar, Gujarat	Artificial fish habitat based marine ecosystem restoration in the inshore areas off Bhadreshswar, Kutch District, Gujarat.	Sreenath K R	In progress	359.37
1007871	Chief Executive Officer, Dept. of Fisheries, Union Territory of Lakshadweep, Kavaratti- 682 555	Setting up of Modern Aquarium at Dept. of Fisheries, Union Territory of Lakshadweep, Kavaratti.	M.K. Anil	In progress	54.7
1008004	Mangalore Refineries and Petrochemicals Limited (MRPL), Mangalore	Seawater and treated effluent monitoring of M/s MRPL	Prathibha Rohit	In progress	13.28
1008767	M/s JSW Jaigarh Port Limited, JSW Centre, Bandra Kurla Complex, Mumbai -400 051	Assessment of impact on fish production due to development of the Jaigarh Port at Village Jaigarh, Maharashtra,	V. V. Singh	In progress	49.91
1009195	Mangalore Refineries and Petrochemicals Limited (MRPL), Mangalore	Sea water and treated effluent monitoring of M/s MRPL	Prathibha Rohit	In progress	13.34
TOTAL					1018.6

Research management & staff welfare

Research Advisory Committee (RAC)

The 21st RAC meeting was held during 27-28 February 2017 at CMFRI, Kochi. The meeting was attended by :

1. Prof. Dr. N.R. Menon, Co-Chairman, Board of Directors, Nansen Environmental Research Centre (India), Chairman
2. Dr. N. Ramaiah, Chief Scientist, National Institute of Oceanography, Goa, Member
3. Dr. A.R. Thirunavukkarasu, Principal Scientist (Retd.), CIBA, Chennai, Member
4. Dr. Madan Mohan, ADG (Marine Fisheries, Retd.) ICAR, New Delhi, & Director of Fisheries, Punjab, Member
5. Dr. S.K. Chakraborty, Principal Scientist (Retd.), CIFE, Mumbai, Member
6. Dr. V.N. Sanjeevan, former Director, Centre for Marine Living Resources, Kochi, Member
7. Dr. Pravin Puthra, ADG (Marine Fisheries), ICAR, New Delhi, Member
8. Dr. A. Gopalakrishnan, Director, CMFRI, Member
9. Dr. P. Vijayagopal, Head in Charge & Principal Scientist, MBTD, CMFRI, Kochi, Member Secretary along with HOD's and SIC's.

Dr. A. Gopalakrishnan welcomed Hon'ble Chairman, Dr. N. R. Menon, all the RAC members, Heads of Divisions, Scientists-in-Charge of all the Regional and Research Centres of CMFRI. In his welcome address, Dr. Gopalakrishnan expressed happiness at having

Drs. Pravin, ART Arasu, Ramaiah N, NR Menon, Gopalakrishnan A, Madan Mohan, SK Chakraborty (L to R)

Prof. Dr. N.R. Menon as the Chairman and his teachers as the Committee members. Dr. Gopalakrishnan gave the salient achievements of the Institute. He mentioned that there are 11 research Centres including the new research Centre at Digha. There are 17 field Centres with the addition of two, one at Mandvi and the other at Paradeep. The Institute has a new mandate and 33 in-house, 37 externally funded and 13 consultancy projects. The research achievements from different divisions were also highlighted which he said will be presented in detail by the respective Heads of divisions. He also enlightened the members about the staff strength of the Institute and the several publications/products that were brought out this year.

Dr. Pravin appreciated the efforts of the Institute in bringing out two mobile app mKrishi and Fish finder which is in tune with digital India initiatives of Prime Minister.

The Action Taken Report of the Recommendations of the 20th RAC was presented by Member Secretary, Dr. Vijayagopal. This was followed by the presentations by the Heads of Divisions, SICs of Regional Centers and Research Centers.

Recommendations of 20th RAC:

- Seed production of marine food fishes should be more organised with each center focusing on one species each. Mandapam can serve as the nodal center and broodbank with Karwar and Vizhinjam focusing on snappers
- Culture protocols of new live feeds, especially the copepods should be standardised defining the optimum conditions
- Broodstock feeds should be evaluated in the marine food fishes identified by CMFRI
- Economic feasibility and environmental parameters of all cage culture operations should be documented
- FRAD should initiate more studies species-wise to understand changes in fishery over a long period of time
- Picoplankton productivity may be factored into the Chloriffs project
- Marine biodiversity division should embark upon more rigorous specimen collection work with stress on local biodiversity
- FEMD should adopt more of APHA methods in their analyses and more ecological parameters should be incorporated into their studies
- A National Litter Atlas should be brought out by FEMD at the earliest
- Publication of a book/monograph on commercially traded elasmobranchs of India
- The product array developed from seaweeds by CMFRI is recommended to be diversified further
- Species prioritisation should be an ongoing process for mariculture and ornamental aquariculture
- Wealth from waste initiative of KVK-CMFRI should be scaled up
- Two peer reviewed publications from each scientist/ year foreseeing a 10% increase in publication from the current number
- Development of taxa-wise specialists imparting appropriate training to newly recruited scientists
- Algal blooms in Lakshadweep Archipelago should be studied in detail
- Collaboration of CMFRI with NIOT for engineering expertise, especially for shifting of cages during hostile conditions
- Migration of sardines northwards should be correlated with the oceanographic information
- Age assessment studies of long lived fishes should be fine tuned
- IMTA activities at Mandapam needs fine tuning and a protocol, CO2 absorption levels and economics booklet to be brought out soon

Institute Research Council (IRC)

The 23rd IRC meeting was held at CMFRI from 26- 30th April 2016. Progress of research in all in-house projects, network projects, outreach projects and externally funded projects were presented by the project leaders and Heads of Divisions. The Officers-in-charge of the sections and the Programme Coordinator of KVK also presented their work during the year.

23rd IRC meeting

Institute Management Committee (IMC)

The 80th meeting of the Institute Management Committee of CMFRI was held on 7th October 2017 at CMFRI, Kochi. Review action taken on the items considered during the previous review meeting held on 26th February 2106 at CMFRI was done. Members of IMC expressed their satisfaction on the research achievements made by CMFRI. IMC recommended the construction of Farmers Training Hostel at Visakhapatnam RC of CMFRI. Committee also approved outsourcing of security services, recognition of hospitals for medical treatment *viz*., Aster Medicity and Renai Medicity, Cochin for treatment of staff and families. Arokya Hospital, Ramanathapuram was also recommended for treatment of staff and their families at Mandapam RC of CMFRI. The Comptroller NDRI, a member of the Committee appreciated the efforts taken by the Institute in efficient utilisation of funds.

Institute Joint Staff Council (IJSC)

Third meeting of the 13th IJSC of CMFRI held on 1st November 2016 at CMFRI, Kochi discussed and settled various issues of the staff. Action taken on the outstanding items in the second meeting of the 13th IJSC on 29th January 2016 was reviewed. Shri. C. Muralidharan, Chief Administrative Officer presented the action taken report on the agenda items of the second meeting of the 13th IJSC. The staff side expressed satisfaction on action taken and 10 new agenda items and 5 additional agenda items were discussed in the meeting.

Third meeting of the 13th IJSC

Training and capacity building

Annual Training Plan

Annual training plan (ATP) 2016-17 for the various categories of CMFRI employees were prepared after assessing the training needs of individual employees. Based on ATP, 144 training programmes were planned for 2016-17 which includes 31 trainings for Scientific, 58 for Technical, 30 for Administrative category and 25 for skilled support staff.

Achievements

During 2016-17, 70 scientists, 34 technical, 18 administrative and 37 skilled support staff attended various trainings programmes.

Training programmes attended by staff of CMFRI during 2016-17

Name of the training programme	Organisation
Natural resources management system	IIRS, Dehradun
Exploring Gene expression data using Transcriptome and Microarrays	RGCB, Trivandrum
Impact assessment of agricultural extension	NAARM, Hyderabad
Big data analytics in agriculture	NAARM, Hyderabad
GIS & D-GPS	Indian Geo Informatics Centre
Advances in experimental data analysis	IASRI, New Delhi
Essential Ecosysytem approach to fisheries management: Developing capacity in the Ecosystem approach to fisheries management	CMFRI, Kochi
Geosaptial Analysis for Natural Resources Management	NAARM, Hyderabad
Right to Information Act 2005	Institute of Management in Government
Management Development Programme on Leadership Development	NAARM, Hyderabad
Monitoring structure and function of pelagic ecosystem at regional sectors: relevance for fisheries	CMFRI, Kochi
Advances in fish stock assessment methods	CMFRI, Kochi
Next Generation sequence data analysis	CIFA, Bhubaneswar
Agrobiodiversity conservation and sustainable livelihoods	Agrobiodiversity Centre, Wayanad
Aquaculture nutrition and technology	ICAR-CIBA, Chennai
Emotional intelligence at work place for Scientists/Technologists	Centre for Organisation Development, Hyderabad
Public procurement	NIFM, Faridabad
Computer application	IASRI, New Delhi
Experimental data analysis	IASRI, New Delhi
Good Laboratory Practices (GLP)	CIFE, Mumbai
Formulation of budget	ISTM, New Delhi
Handling & maintenance of lab and field equipment for technical staff	CIFE, Mumbai
Establishment rules	ISTM, New Delhi
Administrative vigilance–I	ISTM, New Delhi
Formulation of budget	ISTM, New Delhi

Training programmes

Training programmes organised by CMFRI in various aspects of marine fisheries and mariculture.	
1	Cage culture technology demonstration in brackish water and marine waters
2	Monitoring structure and function of pelagic ecosystem at regional sections: relevance of fisheries
3	Microalgal / Live feed culture
4	Sea weed culture
5	Essential Ecosystem approach to fisheries management: Developing capacity in the ecosystem approach to fisheries management
6	Stock assessment of Tropical fishes
7	Fish stock assessment methods
8	Methods of ecological analysis by statistical softwares
9	Capacity building programme for fisheries department officials
10	Advances in capture fisheries and aquaculture

Training programme on 'Essential EAFM: Developing capacity in the ecosystem approach to fisheries management'

Training programme on 'Essential EAFM: Developing capacity in the ecosystem approach to fisheries management' was organised jointly with BOBP-IGO during 30th August 2016 – 3rd September 2016 at CMFRI Kochi. Purpose of the EAFM training was to provide participants with the concept and principles of EAFM and for them to learn and practice the planning skills involved in developing EAFM plans. Sixteen scientists from CMFRI and trainees from four BOBP member countries such as Bangladesh, India, Srilanka and Maldives attended the training programme. Trainers' Training on EAFM was also given to 6 selected trainees during 5th to 6th September 2016.

Training on Stock Assessment of Tropical Fishes

Two weeks training course on 'Stock Assessment of Tropical Fishes' was conducted at ICAR-CMFRI, to train 12 Officials nominated by the Government of the People's Republic of Bangladesh. The training Course was jointly organised by the ICAR-CMFRI and Bay of Bengal Programme Inter-Governmental Organisation (BOBP-IGO), Chennai during 23 November to 6 December, 2016.

Ph.D. Programmes

During 2016-17, CMFRI signed an MoU with MS university, Tirunelveli for collaborative R & D academic interaction leading to higher qualifications. Through this MoU, MSU has recognised CMFRI, Kochi as a research centre for Ph.D programmes of the university.

Scientists of CMFRI are recognised guides under various reputed universities like Cochin University of Science and Technology (CUSAT), Mangalore University, Mahatma Gandhi University, Andhra University, Madras University and Kerala University

68 scholars are pursuing their doctoral degree programmes at CMFRI, Kochi and its centres under various universities.

Ph.D degree awarded during 2016-17			
Name	Guide	University	Date of award
Mohitha C.	Dr. A. Gopalakrishnan	CUSAT	Thesis submitted on 23.12.2016
Preetha K	Dr. K.K Vijayan	CUSAT	11.11.2016
Subin C.S	Dr. K.K. Vijayan	CUSAT	07.10.2016
Reynold Peter	Dr. P.C Thomas	CUSAT	20.09.2016
Anusree V. Nair	Dr. K.K. Vijayan	CUSAT	30.12.2016
Bineesh K.K	Dr. N.G.K Pillai	CUSAT	08.07.2016
Bini Thilakan	Dr. Kajal Chakraborty	CUSAT	12.05.2017

Distingushed visitors

CMFRI Headquarters, Kochi

Mr. Mathew P. Thomas, Director, Additional Skill Accquisition Programme (ASAP), Govt. of Kerala, Thiruvananthapuram, 05.04.2016

Dr. Trilochan Mohapatra, Secretary (DARE) & DG (ICAR), New Delhi, 18.4.2016

Shri. Chhabilendra Roul, Additional Secretary (DARE) & Secretary (ICAR), New Delhi, 18.04.2016

Mr. A.K. Singh, Head, Division of Genetics, IARI, New Delhi, 20.05.2016

Mr. B.S. Shiksharthi, SPO, CSIR-NISCAIR, New Delhi, 07.06.2016

Smt. J. Mercykutty Amma, Hon'ble Minister of Fisheries, Government of Kerala, 16.07.2016

Mr. N.B.P. Punyadewa, Head, Fishing Technology Division, NARA, Srilanka, 03.09.2016

Dr. Tariq Thomas, IAS, Secretary, Fisheries Union Territory of Lakshadweep, 17.09.16

Dr. Gustav Paulay, Curator, Florida Museum of Natural History, University of Florida, 30.11.16

Prof. Richard Hay, Member of Parliament, Lok Sabha, 28.12.2016

Dr. Thoams Issac, Hon'ble Minister of Finance, 17.01.2017

Justice P. Sathasivam, Hon'ble Governor of Kerala, 18.02.2017

Madras Research Centre

Dr. J.K. Jena, DDG Fisheries, ICAR visited the Kovalam Field Laboratory, 08.07.2016

Mandapam Regional Centre

Mr. S. Natarajan, IAS, District Collector, Ramanathapuram, 03.09.2016

Dr. V.V. Sugunan, Former ADG, ICAR and Senior Consultant, NFDB, Hyderabad, 11.09.2016

Dr (Mrs.) A. Saframma, Head, Department of Hindi, American College, Madurai, 14.09.2016

Mr.S. Murali, Associate Professor, Department of Hindi, Madura College, Madurai, 20.09.2016

Mr.Issac Jayakumar, Deputy Director of Fisheries, Ramanathapuram, 03.11.2016

Dr. Martin Kumar, World Bank Consultant, 12.01.2017

Dr.P.S.B.R.James, Former Director, ICAR-CMFRI, 03.02.2017

Prof. M. Salihu, Former Vice Chancellor, Madurai Kamaraj University, 03.02.2017

Tuticorin Research Centre

Shri. V. Prabhakar IFS, Asst. Principal Conservator of Forest (Vigilance), Forest Department, Chennai, 12.05.2016

Dr. J. K. Jena, DDG (Fisheries), ICAR, New Delhi, 17.06.2016

Shri. Vismiju Vishwanathan, IFS, District Forest Officer, Kanyakumari, 09.02.2016

Shri. Deepak Jacob IAS, Sub Collector, Thoothukudi, 03.02.2017.

Vizhinjam Research Centre

Dr. S. Dam Roy, Director, CARI, Port Blair, 05.04.2016

Dr. S..Chakrabarti, Director, CPRI, Shimla, 06.04.2016

Shri. Hareesh Nair, Under Secretary, ICAR, New Delhi, 23.05.2016

Dr. Som Dutt, Editor, DKMA, New Delhi, 03.05.2016

Prof. P. Natrajan, Professor and Director, Ambo University, Ethiopia, 08.08.2016

Dr. B. Vasanthakumari, Professor of Botany, Sree Ayyappa College for Women, Nagercoil, 08.08.2016

Dr. Jayashree, K. V., Assistant Professor of Zoology, Sree Ayyappa College for Women, Nagercoil, 08.08.2016

Shri. V.K.Varghese, Commandant, Commanding Officer, Indian Coast Guard Station, Vizhinjam, 25.08.2016

Shri. E. T. Mohamad Basheer, MP, Former Minister for Education, Govt. of Kerala,31.08.2016

Dr. V. V. Sugunan, Former ADG, ICAR and Senior Consultant, NFDB, Hyderabad, 26.09.2016

Shri. Sudarshan Bhagat, Hon'ble Union Minister of State for Agriculture and Farmers Welfare, 21.04.2016

Dr. Shashi Tharoor, Member of Parliament, Thiruvananthapuram, 22.04.2017

Dr. Ian W. Low, Principal Scientist, International Potato Centre, Nairobi, Kenya, 18.05.2017

Shri. Abhai Sinha, Director General, CPWD, New Delhi, 05.07.2017

Mumbai Research Centre

Dr. S. D. Singh, Former ADG., ICAR, New Delhi, 08.01.2016

Dr. Asfa M. Yasin, Prof. & Head, Center for International Relations, PSSCIVE, NCERT, Shyamla Hills, Bhopal, 13.01.2016

Mr. David S. Boxer, Environment, Climate & Science Unit Chief, Economic, Environment, Science & Technology Section, US embassy, New Delhi & Ms. Priya Ghose, Environment Specialist, 11.02.2016

Shri. Chhabilendra Roul, Additional Secretary (DARE) & Secretary (ICAR), New Delhi, 05.03.2016

Dr. Rita Pandey, Professor, National Institute of Public Finance and Policy (NIPFP), New Delhi, 05.05.2016

Dr. Trilochan Mohapatra, Secretary (DARE) & DG (ICAR), New Delhi, 07.05.2016

Dr. B. Meenakumari, Chairperson, National Biodiversity Authority, 20.05.2016

Mr. Thomas Beck, Garmin Singapore Pvt. Ltd., 14.07.2016

Dr. J.K. Jena, DDG (Fisheries) ICAR, New Delhi, 18.07.2016

Shri. Yuvraj Chougle, Asst. Commissioner of Fisheries, Bandra, 09.09.2016

Dr. Satyendra Tripathi former Director, ICAR-CIFE, Mumbai, 15.10.2016 and 03.02.2017

Dr. Anil Choubey, Scientist-In-Charge, CSIR-NIO, Mumbai, 15.10.2016 and 03.02.2017

Dr. S.K. Chakrabroty, former Principal Scientist ICAR-CIFE, Mumbai and Member RAC, CMFRI, 03.02.2017.

Ms. Annie Alexander, DGM, NABARD, 17.03.2017

Veraval Regional Centre

Dr. P. Paul Pandian, Fisheries Development Commissioner, Department of Animal Husbandry, Dairying and Fisheries, 03.02.2017.

Dr. Ajay Kumar IAS, Collector and District Magistrate, Gir Somnath, 03.02.2017.

Shri. N. R. Patel, Deputy Commissioner of Fisheries, Gujarat, 03.02.2017.

Major events

a. Dr. Gopalakrishnan welcomes the Hon'ble Governor of KeralaJustice P. Sathasivam on the occasion of the inauguration of the Platinum Jubilee Celebrations, 18 February 2017

b. Participants along with faculty of the BOBP sponsored international training programme (23 Nov – 6 Dec 2016)

c. Exchange of MoU between Dr. A. Gopalakrishnan, Director, CMFRI and Prof. (Dr.) K. Bhaskar, Vice Chancellor, MS University, Tirunelveli recognising Thoothukudi Research Centre of CMFRI as the University's Research Centre

d. Press release of CMFRI data on fish landings

e. Dr. George John, former Advisor, DBT inaugurates the DBT sponsored training programme on Marnie biotechnology for fisheries professionals

f. Hon'ble Director General, ICAR and Secretary DARE, Dr. Trilochan Mohapatra addressing CMFRI staff, 18 April 2016

g. Dr. Thomas Issac, Finance Minister, Govt. of Kerala at CMFRI, Kochi 17 January 2017

h. CMFRI sports team - Winners of ICAR South Zone championship

i. Theeranaipunya training programme participants and faculty

j. Smt. J. Mercykutty Amma Hon'ble Minister of Fisheries, Govt. of Kerala at CMFRI 16 July 2016

k. Newly inaugurated Digha Research Centre of CMFRI

Women cell activities

The women cell of CMFRI, Kochi celebrated International women's day on 9 March 17 by organizing a talk on "Be bold for equality" by Adv. Sujatha Varma, President, Mathrubhumi Grihalekshmivedi. Dr. A. Gopalakrishnan, Director, CMFRI in his presidential address emphasised on the facilities provided to women staff in the Institute and offered all support for the activities of women cell. Dr. Somy Kuriakose, Chairperson and Dr. N. Aswathy, Secretary, Women cell also spoke on the occasion.

Adv. Sujatha Varma addressing CMFRI staff

Marine biodiversity museum

Museum Deposits during 2016

A total of 55 species including three holotypes were deposited in the Marine Biodiversity Museum which comprised of 35 fishes, 7 Cnidarians, 5 molluscs, 5 crustaceans and a turtle and sea snake. The holotypes deposited were *Tenuiproboscis keralensis, Auerbachia ignobili* and *Upeneus* sp. *Aluterus scriptus, Colletteichthys dussumieri, Himantura gerrardi, Paramonacanthus frenatus, Channa striata, Pomadasys furcatus, Taenioidesan guillaris, Alepes vari* and *Carcharhinus amblyrhincos* collected from the fish landing centres of Fort Kochi, Cochin Fisheries Harbour, Kalamukku and Munambam were the notable fish species deposited in the Marine Biodiversity Museum of CMFRI.

Visitors to the Museum

A total of 16622 persons visited the Marine Biodiversity Museum, CMFRI, Kochi during the year 2016. About 7978 Students from 117 Schools and 5089 students from 121 colleges visited the Museum.

Month	Number of school students	Number of college students	Number of Public	Total
January	1057	290	148	1495
February	977	1692	333	3002
March	248	620	178	1046
April	128	208	239	575
May	100	93	436	629
June	45	24	159	228
July	734	80	88	902
August	342	573	183	1098
September	492	526	111	1129
October	1869	253	209	2331
November	1292	449	226	1967
December	694	281	1245	2220
Total	7978	5089	3555	16622

Krishi vigyan kendra

Satellite pearl spot seed production units with NFDB assistance

KVK established pearl spot seed production units in the district with financial assistance from National Fisheries Development Board (NFDB). Progressive farmers from Ernakulam District were selected and trained on seed production and established seed production units in these farms. Accreditation and inauguration of seed production units were done by Prof. K.V. Thomas MP while Adv. V.D. Satheeshan handed over the KVK accreditation certificates to farmers on 5th January, 2017.

Prof. K.V. Thomas MP inaugurating the first sale of Pearl spot seed

Training programme on horticultural mechanisation

KVK jointly with Regional Centre of ICAR-Central Institute of Agricultural Engineering (CIAE), Coimbatore conducted one day training programme on Horticultural Mechanisation for women farmers on 29th June, 2016 at CMFRI, Kochi. Dr. A. Gopalakrishnan, Director, CMFRI distributed certificates.

Skill development training to fisherwomen

A four days skill development training programme on production, packaging and marketing of fish products to fisherwomen with the financial support from Society for Assistance to fisherwomen (SAF) from 23rd to 27th August 2016 was cnducted. Twenty four fisherwomen of Vypeen Island participated in the programme.

Skill development training on safe to eat vegetable production

Skill development training on safe to eat vegetable production to Joint Liability Groups (JLGs') formed by Poverty Alleviation Unit, Ernakulam was conducted. Total of 228 farmers from Vypeen block panchayath were trained on 31st August and 6th September, 2016. Subsequently field trainings and hands-on demonstrations were launched as part of the programme on 22nd September 2016 at Kuzhupilly Block Panchayat hall. The field training was inaugurated by Vypeen block Panchayat president Dr. K.K.Joshi.

a. Demonstration of Potting mixture preparation during the training on Horticultural mechanisation
b. Demonstration of value addition of fish during SAF sponsored Skill development training programme

a. Skill development training on Safe to eat Vegetable production to JLGs
b. Inaugural session of open elective course on Organic farming and Sustainability at CMFRI

Open elective course on organic farming: Joint initiative of KVK and Amrita School of Arts and Sciences

An open elective course for Amrita School of Arts and Sciences, Kochi on Organic farming and sustainability was launched on 1st September, 2016 at CMFRI. Total of 90 students attended the course. The course is launched with an objective of creating awareness among youngsters on the importance of organic farming and safe food production and to make them vigilant about the various issues faced due to over usage of chemical fertilizers, pesticides, use of hormones, etc., in agriculture and allied fields.

Training on organic vegetable cultivation in Rainshelters

Organised training on "Organic Vegetable cultivation in Rain shelters" at CMFRI on 25th and 26th May 2016. Experts from KVK and Kerala Agricultural University took classes during the programme. Exposure visits to best rainshelter farming units were also part of the training.

Sales melas

Total of eight sales melas were organised by KVK at CMFRI and a total of 2200 farmers benefited. Good quality vegetable seedlings, seed propagated curry leaf seedlings, Drumstick, Papaya, Mango, Jackfruit, Jamba, Rambutan, Cherry, Guava, Sapota, Sitaphal seedlings and Kadaknath chicks were distributed to farmers during these melas.

Celebration of World fisheries day and launching of Aqua Task force

World fisheries day was celebrated on 21st November 2016 at Pizhala Island, Ernakulam. During the programme, also launched "Aqua Task Force" *viz.*, Kadamakudy Malsya Krishi Karma Sena to offer services of technically qualified farm labour to help boost fish culture

a. Kadaknath sales mela at CMFRI
b. Participants of training on organic vegetable cultivation in rainshelters

Launching of Aqua Task force Dr. A. Gopalakrishnan, Director, CMFRI

especially cage culture. A seminar on fish farming and cage aquaculture was also part of the World fisheries day programme. A handbook on FAQs on cage farming and a leaflet on GIFT Tilapia farming in regional language were released.

Layer poultry feed for safe egg production

As part of Self farming for safe food programme, KVK released layer poultry feed in 10 kg packets. Dr. A. Gopalakrishnan, Director, CMFRI released the feed by giving packets to poultry farmers on 30th May 2016 at CMFRI, Kochi.

World soil day

World soil day celebration was held at Palluruthy, Ernakulam on 5th December 2016. Shri K.J. Maxy, MLA inaugurated the programme. Yearly calendar for Nutmeg farming indicating month-wise recommendations was also released during the programme and a seminar on soil test based fertilizer application followed.

Seminar on controlling giant African snail

A seminar was organised by KVK on controlling the Giant African snail menace at Government Guest House, Ernakulam on 11th July , 2016. Prof. K.V. Thomas, Hon'ble MP inaugurated the programme. Public representatives from local self governments, Scientists from CMFRI, Kochi, Kerala University of Fisheries and Ocean Studies, Panangad and KVK, Idukki attended the seminar. KVK demonstrated different eco-friendly methods for controlling Giant African Snail.

KVK to form two Farmer producer companies

KVK has registered Pokkali Farmer Producer Company Limited and Periyar Valley Spices Farmer Producer Company Limited with financial assistance from National Bank for Agriculture

a. Dr.A.Gopalakrishnan, Director, CMFRI releasing Poultry layer feed

b. Shri. K. J. Maxy MLA releasing Annual calendar on Nutmeg farming

and Rural Development (NABARD). NABARD has recognised KVK Ernakulam as a Producer Organisation Promoting Institution (POPI). One company is focusing on Nutmeg and other on Pokkali related business ventures. First meeting of FPO Pokkali and Nutmeg FPOs were organised at CMFRI on 2nd May 2016 and 8th June 2016 respectively. Eighty progressive farmers from Ernakulam Dstrict attended the meeting.

Drip irrigation kit - Irrigateasy

A micro irrigation kit suitable for irrigating kitchen gardens upto 1 cent area or 80 growbags was released at Palluruthy on 5th December 2016. The unit can be connected to existing plumbing line or to separate water storage.

Exposure visits

As part of the exposure visit, 19 students of Department of Aquaculture, PMS Calicut University Center, Androth Lakshadweep visited KVK and attended one day training on "Aquaculture prospects and practices" on 25th October 2016 at Narakkal campus.

Biological management of aquatic weeds in public ponds

KVK demonstrated an innovative and ecofriendly method for biological management of aquatic weeds in public ponds by growing certain species of freshwater fish which feed on aquatic weeds. Demonstration was conducted at Thripunithura, Perunninakkulam Shiva temple pond, which has an extent of 1.2 acre. Grass carp fish fingerlings and juveniles were released during a function held on 6th December 2016. The programme was inaugurated by Dr. A. Gopalakrishnan, Director, CMFRI.

Scientific Advisory Commitee meeting of KVK

The Scientific Advisory Committee (SAC) meeting of KVK was held at CMFRI, Kochi on 6th January, 2017. Director CMFRI presided over the meeting. Review of the work done by KVK was done by Zonal Project Director Dr. Sreenath Dixith in the presence of SAC members. Future courses of action in year 2017-18 was also discussed in the meeting.

a. Exposure visit of students of PMS Calicut university Center, Androth, Lakshadweep
b. Dr A. Gopalakrishnan, Director, CMFRI inaugurating the programme "biological management of aquatic weeds in public ponds"

Awareness programme on *Pradhan Mantri Fasal Bhima Yojana* (PMFBY) crop insurance scheme

KVK conducted a district level awareness programme on PMFBY, the new Crop Insurance scheme launched by Government of India. The awareness programme was inaugurated by Prof. K. V. Thomas MP, Ernakulam at Kottuvally on 28th June 2016.

Accreditation by Agricultural Skill Council of India (ASCI)

The Agricultural Skill Council of India (ASCI) has accredited KVK for conducting skill training programmes under *Pradhan Mantri Kaushal Vikas Yojana* (PMKVY), programme. During 27th February to 27th March, 2017 KVK conducted two training courses of 25 days duration for 20 candidates each on the topic "Aquaculture technician" and "Vermicompost Producer". The programme is a part of PMKVY, a unique initiative by the Government of India that aims to offer meaningful, industry relevant, skill based training to 24 lakh Indian youth.

Radio programme

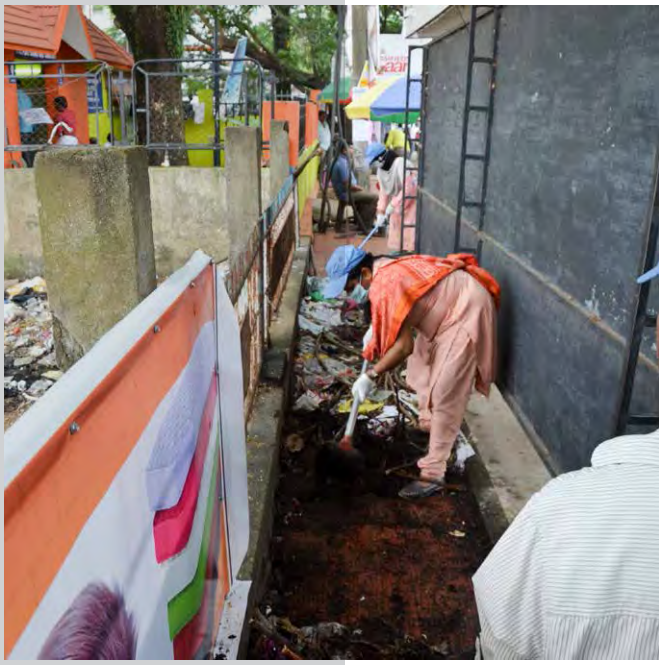
- Dr. A. Gopalakrishnan, Director CMFRI, Dr.Shinoj Subramannian, Sr.Scientist and Head and Smt. K. Smita Sivadasan Subject Matter Specialist (Animal Husbandry) participated in a radio programme on *Karinkozhi Vipanana Mela* in AIR, Kochi 102.3 FM broadcasted on 6th April 2016.
- Dr. Shinoj Subramannian, Sr. Scientist & Head and Dr. Shoji Joy Edison, Subject Matter Specialist (Horticulture) delivered a talk on "Rainshelter cultivation and coverage of rainshelter training conducted by KVK' broadcasted in AIR, Kochi 102.3 FM on 10th June 2016.
- Dr. P. A. Vikas, Subject Matter Specialist (Fisheries) delivered a talk on "GIFT Thilapia farming prospects" in AIR, Kochi 102.3 FM on 27th May 2016.

a

a. Prof. K. V. Thomas MP distributing Vegetable seed kit during PMFBY programme
b. ASCI training on Vermicompost Producer
c. ASCI training on Aquaculture Technician

b

c



Swachh Bharath Abhiyan

Under the Swachh Bharath Abhiyan, CMFRI was provided with an innate opportunity to augment our plans for which befitting programmes were conceived to generate awareness, demonstrate cleanliness drive, develop technologies supporting waste management in fisheries and brief the media with press releases dedicating to the central themes of "*Swachh Bharath*". During the period, CMFRI teamed with different governmental and non-governmental agencies and ensured developing wider participation with the target populace including coastal communities and public. CMFRI showcased the need for 'Clean India' through its various programmes which includes cleanliness drives across the public utility avenues, developing technologies

aimed at waste reduction, imparting awareness and reaching out to public through media and involvement of children and youth and by inviting inspiring change agents and showcasing changes manifested from civic societies.

CMFRI Swachh Pakhwada activities were held during 17-31 October 2016. The "*Swachh Pakhwada*" commenced on Gandhi Jayanthi and culminated on the Rashtriya Ekta Divas (31st October 2016) with activities implemented within a well-conceived action plan across CMFRI Headquarters and its ten regional/ research centres. *Swachhta Shapath* was taken by all the participants and committed to make self, community, society, villages and cities clean towards joining the country in exemplary list of the countries in the world. The programme ranged from cleaning the public utility areas like harbour, hospitals, schools, parks, beaches, bus shelters, boat jettys, public walkways, playgrounds, cleaning the office premises, tree plantation, vegetable gardening, decomposition of degradable and non-degradable waste; developing products and processes leading to waste reduction, usage of eco-friendly technologies as well as lesser use of plastics, creating awareness among public entities, floated a human chain to create awareness on Clean India campaign with a participation of around 500 staff members from CMFRI, PMFGR of NBFGR and CIFRI, conducting competitions in this connection, awareness on Yoga/Health/positive thinking/water conservation and so on. One of the hallmarks of Swachh Bharath Abhiyan activities has been developing fruitful linkages with the civic societies and other government agencies in partnering with them for future initiatives. Shri. Deepak Joy, Ward Councillor, Ayyapapankavu, Cochin Municipal Corporation was the Chief Guest for the Valedictory function of the Swachhta Pakhwada held at CMFRI, Kochi on 31st October 2016.

Various activities were initiated and conducted which includes installation of a biogas unit at Mangalore Research Centre for converting the fish waste which is coming regularly from the fish analysis and is functional. Biodegradable waste were dumped in compost pit for further use as compost and non-degradable wastes were disposed in the municipal waste yard. Part of the compost pit was converted to biogas slurry manure preparation unit. Cleaning of office premises and the garden de-weeding is being carried out at regular intervals. Preparation

of vegetable patch for new planting and seeding vegetable varieties and usage of manure procured from vermicomposting was done. Complete eradication of '*seemai karuvelam*' (*Prosopis juliflora*) within the premises and surrounding areas of Mandapam Regional Centre. Cleaned mangrove forests located by side of the backwaters in KVK campus and huge quantities of plastic wastes removed from the root zone of mangrove ecosystem which is the natural habitat and breeding place for brackishwater fish species. Lectures by prominent people in respective areas on topics based on *Swachh Bharath* were conducted for creating awareness. Other activities conducted were:

- Beach cleaning programme and an elocution competition on "CLEAN INDIA DAY" for school children
- *Swachh Bharat Rangoli* competition
- Awareness programme for school children, awareness workshop for fisher women on cleanliness of fish market and other fish processing and fish selling areas
- Inspection of office premises and hatchery by the field officials from the office of the District Medical Officer, Department of Health, Government of Kerala was carried out at the Vizhinjam Research Centre of CMFRI, Vizhinjam
- Minimised the use of plastic and most of the commonly used plastic materials such as water jugs, tumblers, containers are replaced with ecofriendly biodegradable materials
- Placards in English and Kannada (local language) were prepared and distributed to school children, State Fisheries Departments and Fisheries Union Offices
- Awareness placards were displayed prominently at Mangaluru Fisheries Harbour

In continuation to the *Swachh Bharat Abhiyan* activities, CMFRI will carry on to strive for a Clean India in the long run.






Official language implementation

Awards and Achievements

Rajarshi Tandon Puraskar of ICAR

CMFRI bagged Rajarshi Tandon Award introduced by ICAR for the excellent Official Language activities among the Institutes situated in 'C' Region, for the 7th time in the year 2014-2015. Dr. A. Gopalakrishnan, Director, CMFRI received the Award from Shri Parshottam Rupala, Hon'be Union Minister of State for Agriculture & Farmers Welfare in presence of Shri Sudarshan Bhagat, Hon'be Union Minister of State for Agriculture & Farmers Welfare and Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR during the ICAR Foundation Day Program organised at Vigyan Bhavan, New Delhi on 16th July 2016.

Kochi TOLIC Rajbhasha Rolling Trophy

CMFRI, Kochi bagged Rajbhasha Rolling Trophy (2nd position) of Kochi Town Official Language Implementation Committee for the best implementation of Official Language during 2015-16. Award was distributed in the meeting held in the Conference Hall of CIFNET, Kochi on 18th January 2017 by Dr. Radhikadevi, Principal, Dakshin Bharat Hindi Prachar Sabha, Kochi. Shri Narendra Singh Mehra, Assistant Director (Implementation), Implementation Office, Department of Official Language, Kakkanad and Shri K.K. Ramachandran, Deputy Director (OL), Income Tax Office, Kochi were also present in the function.

Shri C. Muralidharan, Chief Administrative Officer and Shri Navin Kumar Yadav, Assistant Director (OL) receiving the Rajbhasha Trophy

Karwar TOLIC Rajbhasha Rolling Trophy

Karwar Research Centre of CMFRI won the Award for implementation of Official Language among the Central Government offices located in Karwar. Dr. S.R. Krupesha Sharma, Principal Scientist received the Award from Shri Tekchand, Dy. Director (Implementation), Department of Official Language, Bengaluru on 30th June, 2016 during the Half yearly meeting of Karwar TOLIC.

Dr. Krupesha Sharma receiving Karwar TOLIC Rajbhasha Rolling Trophy

Extension activities

Hindi Chethana Mas Celebration–2016

To encourage staff members to do their Official work in Hindi and to propagate the use of Official Language, Hindi Chethana Mas 2016 was celebrated from 01 to 29 September, 2016 with various competitions such as Hindi Noting, Drafting & terminology, Hindi Cross word, Quiz and News reading in Hindi.

The valedictory function of Hindi Chetna Mas was organised on 30th September 2016 with Smt. Varsha Godbole, Regional Manager, National Insurance Company Ltd., Ernakulam as the Chief Guest. Dr. R. Narayanakumar, Head, SEETT Division delivered presidential address. Shri Navin Kumar Yadav, Assistant Director (OL) read out the message of Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture & Farmers' Welfare and Shri Rajnath Singh, Hon'ble Union Minister of Home Affairs. Chief Guest distributed prizes to the winners of competitions. Under CMFRI special incentive scheme, cash incentives were presented to 6 officers and staff at Headquarters. Rajbhasha Rolling Trophy was awarded to Marine Biodiversity Division.

Hindi Week/Fortnight was also celebrated in all Regional and Research Centres of CMFRI with various programmes and competitions.

Presidential address by Dr. R. Narayanakumar, Head, SEETT Division

Joint Official Language Celebration-2016

Officers and staff of the Institute participated in various competitions of Kochi Town Official Language Implementation Committee Joint Official Language celebration-2016 held at Income Tax Office, Kochi and won prizes.

Radio Talk in Hindi

Dr. K.K. Joshi, Head, MBD delivered a radio talk in Hindi on 'Coastal Biodiversity and Environment' in AIR, Kochi, which was telecasted by AIR Vigyan Bharati, New Delhi on 27th July 2016.

Hindi workshops

Inorder to promote Spoken Hindi among staff members and to increase the use of Official Language in day to day work, Hindi workshops were conducted at Headquarters, Kochi as well as at outstations as follows:

- Headquarters, Kochi : 14 June 2016, 4 July 2016, 8 December 2016 and 8 February 2017.
- Mandapam RC : 20 June 2016, 28 September 2016, 29 December 2016 and 29 March 2017
- Visakhapatnam RC : 9 March 2016
- Veraval RC : 24 August 2016
- Madras RC : 27 June 2016, 30 August 2016, 21 December 2016 and 30 March 2017
- Tuticorin RC : 24 May 2016, 23 July 2016 and 25 January 2017
- Mangalore RC : 29 June 2016 and 29 September 2016.
- Mumbai RC : 22 April 2016, 27 August 2016, 22 October 2016 and 8 March 2017
- Karwar RC : 30 September 2016 and 21 March 2017
- Vizhinjam RC : 25 June 2016
- Calicut RC : 25 June 2016, 30 August 2016 and 30 December 2016

Meetings

Quarterly meetings of Official Language Implementation

During the period, 4 meetings of the Official Language Implementation Committee of the Institute were conducted on 11 April 2016, 5 July 2016, 5 October 2016 and 31 January 2017.

Half yearly meeting of Town Official Language Implementation Committee

Participated in meeting of Town Official Language Implementation Committee at Income Tax Office, Kochi on 18 January 2017.

Hindi workshop at:
a) Headquarters, Kochi
b) Mangalore RC
c) Vizhinjam RC

Training

Assistant Director (OL) attended 5 days High Level Translation Training course conducted by Central Translation Bureau, New Delhi during 09-13 January, 2017.

Inspections

Inpection by ICAR

Shri Manoj Kumar, Assistant Chief Technical Officer, ICAR inspected the Official Language implementation activities of CMFRI on 6 April, 2016.

Official Language inspection at Outstations

Official Language implementation activities of Vizhinjam Research Centre was inspected by Dr. Imelda Joseph, Principal Scientist on 9 January 2017, Madras Research Centre and Visakhapatnam Regional Centre by Shri Navin Kumar Yadav, Assistant Director (OL) on 22 and 24 March 2017 respectively.

Review of Official Language implementation activities of Outstations

The Official Language implementation activities of all Regional and Research Centres were reviewed in every quarter and necessary suggestions were given for improvement.

'*PARANGAT*' training

With a view to make staff members proficient in Hindi the session of new training 'PARANGAT' by Department of Official Language was conducted in the Institute in July, 2016. Nine staff members were trained and passed the examination.

Special focus to complete obligatory Training in Centres in Tamil Nadu

Scientists, Technical and Administrative staff of Mandapam Regional Centre of CMFRI passed Hindi Prabodh and Praveen courses and cash incentives were sanctioned.

A word a day

Under 'A word a day' programme, a total of 293 Hindi words with English equivalents were displayed on Electronic display board and circulated among staff members of Headquarters and Outstations.

Bilingualisation and targets of correspondence

During the period, all the documents (1090) under Section 3(3) of Official Language Act 1963 were issued in bilingual format. All letters (2966) received in Hindi were replied in Hindi. Percentage of Hindi correspondence during the year was 58.59% against the target of 55%.

Under bilingualisation programme during the period, 27 name plates, 16 Rubber stamps, 58 Identity cards of staff members, 3 Charts, Certificates of Headquarters and KVK training programmes, Banners of various programmes were prepared bilingually.

Institute Publication in Hindi

CMFRI Newsletter Cadalmin – Issue Nos. 148, 149, 150 & 151

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Reports

CMFRI 2016. *Marine fish landings in India 2015*, Technical Report, Fisheries Resources Assessment Division, Central Marine Fisheries Research Institute, Kochi

Dinesh Babu, A.P., Maheswarudu, G., Sujitha Thomas, Lakshmi Pillai, S. and Sobha Joe Kizhakudan 2017. *GIS based inventory of marine fish landing centres and fishing operations along the Indian coast as a baseline information for marine spatial planning*. Central Marine Fisheries Research Institute, Kochi, 118 pp

Mohamed, K.S., Asokan P.K., Geetha Sasikumar, Kaladharan, P., Kripa, V., Sanil, N.K., Shelton Padua, Prema, D., Venkatesan, V., Jenni, B., Sajikumar, K.K., Anasukoya, A., Alloycious, P.S. and Jestin Joy 2016. *Recommendations to resolve the crisis in mussel farming in Padanna Backwaters*, Kasaragod, Kerala. Submitted to Govt. of Kerala, Central Marine Fisheries Research Institute, Kochi, 39 pp

Rekha J. Nair and Aswathy, N. 2016. *2015-le Keralathile matsyabandanavum matsyasambathum. Technical Report*, Central Marine Fisheries Research Institute, Kochi

Shyam S. Salim 2017. *Theeranaipunya-Capacity building training programme for fisherwomen: A CMFRI-SAF Initiative 2016 -2017*. Central Marine Fisheries Research Institute, Kochi

Shyam S. Salim, Reeja Fernandez and Athira, N.R. 2016. *Performance Appraisal of Theeramythri initiatives in Kerala: Benefit monitoring assessment and visioning for the future*. Central Marine Fisheries Research Institute, Kochi

Vinod K., Asokan, P.K., Zacharia, P.U., Kaladharan, P., Singh, V.V., Dineshbabu, A.P., Sanil, N.K., Sawant, D.D. and Anasu Koya, A. 2016. *A strategic assessment of mud crab farming potential in brackishwater stretches between Velas and Dabhol in the Ratnagiri District of Maharashtra*. Central Marine Fisheries Research Institute, Kochi

Posters

Gyanaranjan Dash, Pradhan, Rajesh Kumar, Swatipriyanka Sen Dash, Mohammed Koya, K., Vinaya Kumar Vase, Sreenath, K.R., Divu, D., Kapil Sukhdhane, S., Bharadiya Sangita, A., Vipul Solanki and Jayshree Gohel, K. 2017. *Commercially important crustaceans of Gujarat*. CMFRI Poster No. 31/2017

Mohammed Koya, K., Bharadiya Sangita, A., Pradhan, Rajesh Kumar, Sreenath, K.R., Swatipriyanka Sen Dash, Gyanaranjan Dash, Vinaya Kumar Vase and Sukhdhane, Kapil, S. 2017. *Commercially important Shads, Herrings and Anchovies of Gujarat*. CMFRI Poster No. 32/2017.

Rajesh Kumar Pradhan, Mohammed Koya, K., Gyanaranjan Dash, Swatipriyanka Sen Dash, Vinaya Kumar Vase, Sreenath, K.R., Divu, D., Kapil Sukhdhane, S., Vipul Solanki and Bharadiya Sangita, A. 2017. *Commercially important Cephalopods of Gujarat*. CMFRI Poster No. 30/2017

Sajikumar, K.K., Venkatesan, V., Jestin Joy, K.M., and Mohamed, K.S. 2016. *Oceanic cephalopod fauna of Southeastern Arabian Sea*. CMFRI Poster No. 19/2016

Swatipriyanka Sen Dash, Bharadiya Sangita, A., Rajesh Kumar Pradhan, Mohammed Koya, K., Vinaya Kumar Vase, Gyanaranjan Dash, Divu, D. and Jayshree Gohel, K. 2017. *Commercially important Sharks of Gujarat*. CMFRI Poster No. 33/2017.

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Swatipriyanka Sen Dash, Bharadiya Sangita, A., Rajesh Kumar Pradhan, Mohammed Koya, K., Vinaya Kumar Vase, Gyanaranjan Dash, Kapil Sukhdhane, S. and Jayshree Gohel, K. 2017. *Commercially important Rays and Skates of Gujarat.* CMFRI Poster No. 34/2017

Vinod, K., Murugan, A., Vivekanandan, E. and Asokan, P.K. 2016. *Life Cycle of Seahorse*

Leaflets

Akhilesh, K.V., Mhatre, V.C., Pawar, B.B, Khandagale, P.A., Anulekshmi, C., Ramkumar, S., Ratheesh, Kumar, R., Nakhawa, A. and Singh, V.V. 2016. *Glimpses of open sea cage culture in Maharashtra*

Anulekshmi, C., Sarang, J., Kamble, S., Vaibhav Mhatre, Nilesh Pawar, Khandagale, P., Ramkumar, S., Akhilesh, K.V., Ajay Kumar Nakhawa, Ratheesh, R. and Singh, V.V. 2016. *Cage construction-Principle and design*

Sanil, N. K., Asokan, P.K., Pradeep, M.A., Rithesh Ranjan, Binesh, C.P. and Shamal, P. 2016. *Diseases in mussel farming*-booklet in bilingual format (English & Malayalam).

Shoba Joe Kizhakudan, Geetha, R., Indira Divipala, Yousuf, K.S.S.M., Shanthi, M., Guptha, K.S. and Zacharia, P.U. 2016. *Thamizhnattin kadalora mavattangalil paruva nilai maatramum athan bathippugalum*

Zacharia, P.U. 2016. *Marine climate and fisheries scenario of Tamil Nadu.* CMFRI NICRA Pamphlet (Tamil).

Zacharia, P.U. 2016. *Climate change and vulnerability of coastal villages in Tamil Nadu*

Zacharia, P.U. 2016. *ClimFish NICRA Newsletter*, Vol. II

Videos

Vipinkumar, V.P., Miriam Paul Sreeram, Harshan, N.K., Sunil, P.V., Jeethumol, T.J., Athira, P.V., Narayanakumar, R. and Gopalakrishnan, A. 2017. *Fertifish: A diversified livelihood avenue for women entrepreneurs in Engandiyoor*

Vipinkumar, V.P, Mohamed, K.S., Rekha J. Nair, Ramachandran, C., Grinson George, Boby Ignatius, Jayasankar, J. and Gopalakrishnan, A. 2017. *Seven Decades of CMFRI-A Reminiscence*

Vipinkumar, V.P., Vidya, R., Harshan, N. K., Sunil, P.V. Jeethumol, T.J., Athira, P. V., Narayanakumar, R. and Gopalakrishnan, A. 2017. *Fertifish - Engandiyoorile Vanitha samrambakarku upajeevanam vaividhyavathkaranathiloode* (in Malayalam)

Vipinkumar, V.P., Harshan, N.K, Sunil, P.V., Jeethumol, T.J., Athira, P.V., Narayanakumar, R. and Gopalakrishnan, A. 2017. *Vijayasaphalyam aquatourisathiloode: Mathrukayayi Vypilile Vanitha Swashrayasangangal* (in Malayalam)

Vipinkumar, V.P., Harshan, N.K, Sunil. P.V., Vidya, R., Narayanakumar, R., Athira, P.V., Jeethumol, T.J. and Gopalakrishnan, A. 2017. *Tasting success through Aqua tourism: The chronicle of women SHGs in Vypeen*

Vipinkumar, V.P, Narayanakumar. R., Harshan. N.K., Sunil. P.V. and Gopalakrishnan, A. 2016. *Kumbalangiyile Cheenavala: Vanitha swashrayathinte vijayagatha* (in Malayalam)

Vipinkumar, V.P, Narayanakumar. R., Pushkaran, K.N., Harshan, N.K. and Gopalakrishnan, A. 2016. *Vembanad thadakathil Koodu matsya krishiyude vijayagatha* (in Malayalam)

Vipinkumar, V.P., Priyadarshanan, D., Ajith Thomas, Narayanakumar, R., Harshan, N.K., Sunil, P.V., Vidya, R. and Gopalakrishnan, A. 2016. *Saga on Social Entrepreneurship- A pioneering SHG venture thorough Fish Aggregating Devices*

Vipinkumar, V.P, Priyadarshanan, D., Ajith Thomas, Narayanakumar, R., Harshan, N.K., Sunil, P.V., Athira, P.V., Jeethumol, T.J. and Gopalakrishnan, A. 2016. *Krithrima matsya thavalangal swashryathiloode - Samoohika punarudharanathilekkulla oru chuvaduvaypu* (in Malayalam)

Vipinkumar, V.P, Shinoj, P., Vidya, R., Harshan, N. K., Narayanakumar, R. and Gopalakrishnan, A. 2017. *A shot in the arm for livelihood success story of clam processing women SHGs in Pookaitha*

Vipinkumar, V.P., Shinoj, P., Vidya, R. and Harshan, N.K., Narayanakumar, R. and Gopalakrishnan, A. 2017. *Pookaithayile vanitha swashrayathwam kakka samskranathiloode: Upajeevanathinoru kaithangu* (in Malayalam)

Patents

A process to prepare seaweed concentrate to combat dyslipidemia and a product thereof-Indian patent applied

A process to prepare seaweed-derived hybrid drug delivery system and antibacterial ointment- Indian patent applied

Technologies developed

Nutraceutical to combat dyslipidemia and obesity: Cadalmin™ Anti-hyper cholesterolemic extract (Cadalmin™ ACe) from seaweed: Bioactive pharmacophore leads from seaweeds were used to develop the nutraceutical product, and were found to inhibit hydroxymethyl glutaryl coenzyme A reductase, various target receptors and other rate limiting enzymes, which are responsible to cause obesity and dyslipidemia.

Green drug delivery system and antibacterial ointment from seaweeds: Anti-inflammatory pharmacophore-encapsulated seaweed-derived hybrid drug delivery system for oral drug delivery and topical application. pH behaviour, bioavailibility and cross-linking properties were found to be comparable with the commercially available products. Swelling behaviour and drug release pattern are comparable with synthetics. The product exhibited sustained release of encapsulated drug in the gastric fluid which makes it a biocompatible carrier for the controlled oral drug delivery. Antibacterial ointment was prepared based on seaweed-based active ingredient.

Antimicrobial therapeutic product from seaweed-associated bacterium: Heterotrophic bacterium associated with seaweed was used to isolate antibacterial polyketide compounds with activity against human opportunistic food pathogenic bacteria. This is a promising therapeutic agents against infections with multi-resistant Gram-negative pathogenic bacteria and methycillin resistant *Staphylococcus aureus* (MRSA). Product is available in encapsulated form and is intended to be used as oral application.

Antihypertensive nutraceutical (Cadalmin™ Antihypertensive extract, AHE) from seaweeds: Bioactive lead pharmacophores purified from seaweeds showed no significant difference to inhibit angiotensin converting enzyme-I compared to commercial antihypertensive drug captopril, and were utilised to develop the nutraceutical products to combat hypertension. Time dependent shelf-life studies were conducted to identify the changes in bioactivity profile of the product in an accelerated shelf-life study, which revealed no significant reduction of the anti-angiotensin converting enzyme-I activities and the content of active principles of the formulation after the end of study period. The results with regard to preclinical studies demonstrated a lack of test substance-related general organ or systemic toxicity and hypoglycaemic disorders following oral administration at a dose as high as 2000 mg^{-1} kg^{-1} day^{-1}. Large scale extraction of the active principles from the raw material was optimised in a factory unit. The expression of interest to outlicense the product will be carried out during 2017 for commercial production and marketing.

Commercialisation of Technology

Cadalmin™ ADe: Cadalmin™ ADe containing 100% natural marine bioactive ingredients from selected seaweeds by a patented technology was commercialised with Celestial Biolabs Limited, a GMP/ WHO certified pharmaceutical Company based at Hyderabad on 24th April 2016 for commercial production and marketing. The bioactive ingredients in Cadalmin™ ADe competitively inhibit dipeptidyl peptidase-IV and tyrosine phosphatase 1B thereby hindering the occurrence of type-2 diabetes. The nutraceutical has potential to effectively inhibit various mediators, which are responsible to induce type-2 diabetes through various metabolic pathways.

KVK Publications

Books/Leaflets

Shinoj Subramannian and Pushparaj Anjelo 2016. Sthree souharda kaarshika yantrangalude pravarthanavum paripalanavum. *Krishi Vigyan Kendra Publication Series*, 1: 4.

Shoji Joy Edison, Dipti, N.V. and Shinoj Subramannian 2016. Jaiva pachakkari krishi-nooru dina paripadi. *Krishi Vigyan Kendra Publication Series*, 2: 4.

Shoji Joy Edison and Shinoj Subramannian 2016. *Jaathi krishiyude vaarshika calender (Malayalam)*

Vikas, P.A. and Shinoj Subramannian 2016. *FAQs on cage fish farming (Koodu malsyakrishi).* Krishi Vigyan Kendra Central Marine Fisheries Research Institute, Kochi, 34 pp.

Vikas, P.A. and Shinoj Subramannian 2016. *GIFT tilapia krishi* (Malayalam)

Popular/Technical articles

Smita Sivadasan, K. 2016. Payar vilakal kaalikalkku priyam. *Kerala Karshakan*, 61: 46-47.

Vikas, P.A. and Shinoj Subramannian 2016. Vegam valarum GIFT Tilapia. *Kerala Karshakan*, 62: 56-58.

Participations

Conferences/Meetings/Workshops/Symposia/Trainings/Deputations

Dr. A. Gopalakrishnan, Director

Indo-Norwegian Joint Working Group Meeting, New Delhi, 8 April 2016

Meeting of Directors of ICAR Institutes/Scientists-in-charge of Regional Research Centres/AICRPs of ICAR in Kerala under the chairmanship of Dr. Trilochan Mohapatra, Secretary, DARE & DG, ICAR, Munnar, Kerala, 16 April 2016

Fourth meeting of the committee constituted to suggest Draft National Policy on Marine Fisheries under the chairmanship of Dr. S. Ayyappan, former DG, ICAR, New Delhi, 4 May 2016

Visit to Vizhinjam Research Centre of CMFRI and meeting with the scientists to examine the possibility of establishing NFDB funded National Pompano broodbank facility at the Centre, Vizhinjam, 29 May 2016

Fifth meeting of the committee constituted to suggest Draft National Policy on Marine Fisheries under the chairmanship of former DG ICAR, New Delhi, 1-3 June 2016

Interactive meeting of the Directors of all Fisheries Research Institutes at SMD, Fisheries Division, KAB-II, Pusa, New Delhi, 9 June 2016

Interface meeting between DAHD&F and ICAR, New Delhi, 10 June 2016

Meeting with Chairman of the Committee constituted to suggest Draft National Policy on Marine Fisheries, New Delhi, 14 June 2016

Received the Rajarshi Tandon Award from the Hon'ble Union Minister of State for Agriculture and Farmers' Welfare, Vigyan Bhavan, New Delhi, 16 July 2016

Visited Mumbai Research Centre of CMFRI along with DDG (Fy), ICAR and conducted meeting with staff of the Centre, Mumbai, 18 July 2016

Sixth meeting of the committee constituted to suggest Draft National Policy on Marine Fisheries under the chairmanship of Dr. S. Ayyappan, former DG ICAR, New Delhi, 21- 22 July 2016

IJAS Review meeting and the first meeting of the Sub Group 5 (Live Stock and Aquaculture) of Task Force on Use of Technology for Agriculture Insurance under the Chairmanship of Dr. Dilip Kumar, former Director/ViceChancellor, ICAR-CIFE, 29 July 2016

Attended Independence Day function and hoisted flag at Calicut Research Centre of CMFRI, 15 August 2016

Signed the MoU with Manonmaniam Sundaranar (MS) University, Tirunelveli to recognise Tuticorin Research Centre of CMFRI as a Research Centre of MS University for Ph.D. Programmes, 18 August 2016

Visited Tuticorin Research Centre of CMFRI and reviewed the research and other activities of the Centre, 18 August 2016

Visited Mangalore Research Centre of CMFRI and reviewed the research and other activities of the Centre, 30 August 2016

Doctoral Research Committee meeting, Mangalore University, 30 August 2016

Meeting of the XIX Governing Body of the State Fisheries Resource Management Society (FIRMA), Government Secretariat, Thiruvananthapuram, 7 September 2016

Visited Vizhinjam Research Centre of CMFRI, 7 September 2016

Meeting with DDG (Fy) to discuss on the establishment of Digha Research Centre in West Bengal, New Delhi, 15-16 September 2016

Met the Financial Adviser (DARE) and discussed regarding the proposed Financial Review Meeting of South Zone ICAR Institutes to be held at CMFRI, 23 September 2016

32nd Scientific Advisory Committee meeting of Rajiv Gandhi Centre for Aquaculture,MPEDA, Kochi, 27 September 2016

Meeting of Vice Chancellors, Directors and Senior officers of Agricultural Institutions with Hon'ble Union Minister of Agriculture & Farmers Welfare, Govt. of India, New Delhi, CPCRI Regional Station, Kayamkulam, 29 September 2016

Meeting with the Director General, ICAR at CTCRI, Trivandrum during his visit to CTCRI, 20 October 2016

Final meeting of the Task Force related to the Use of Technology for Agriculture Insurance under the Chairmanship of Dr. Ramesh Chand, Member (Agriculture), NITI Aayog, New Delhi, 24-25 October 2016.

Review meeting of ICAR Network Projects and Outreach Research Projects, NASC, New Delhi, 3-4 November 2016

25th meeting of ICAR Regional Committee No. VIII, Sugarcane Breeding Institute, Coimbatore, 11-12 November 2016

Visited Vizhinjam Research Centre of CMFRI in connection with the visit of Shri Sudarshan Bhagat, Hon'ble Union Minister of State for Agriculture & Farmers' Welfare, 28-29 January 2017

Meeting for Documentation of EFC's of Fisheries Research Institutes, Fisheries Division, KAB-II, Pusa, New Delhi, 6 February 2017

Meeting of Vice-Chancellors of Agricultural Universities and Directors of ICAR Institutes, New Delhi, 14-15 February 2017

Meeting of Time Series Oceanographic Observations Off Mumbai (TSOOM), CSIR-NIO, Goa, 18-19 March 2017

Inauguration ceremony of the new Research Centre of CMFRI, Digha, West Bengal, 25 March 2017

Dr. E.M. Abdussamad, Dr. Geetha Sasikumar and Dr. Shoba Joe K. Kizhakudan Trainers' training in 'Ecosystem Approach for Fisheries Management (EAFM)' jointly organized by BOBP-IGO and CMFRI, Kochi, 5-6 September 2016

Dr. Anulekshmi Chellappan Review Meeting on performance of ICAR Research Institutes and the SAUs located in Maharashtra, Mumbai, 4 July 2016

Dr. P.S. Asha National level Hands-on training workshop on Quantitative Research and Techniques using IBM SPSS, Christ University Nodal Office, Vazhuthakkad, Thiruvananthapuram, 26-28 December 2016

63rd Coastal Management meeting, Collectorate Office, Tuticorin, 22 March 2017

Dr. P.S. Asha, Dr. C. Kalidas and Dr. L. Ranjith International Symposium on Aquaculture and Fisheries, Fisheries College and Research Institute, Tuticorin, 23 September 2016

Dr. Biji Xavier, Dr. Ritesh Ranjan and Dr. L. Loveson Edward International conference on Recent Advances in Aquaculture (RAA-2016), Andhra University, Visakhapatnam, 15-17 December 2016

Shri. K. Diwakar Hindi scientific seminar, Heavy Water Plant, Tuticorin, 30 March 2017

Dr. Geetha Sasikumar Resource person for the training programme on 'Open-sea cage farming and allied activities' organised by Coastal Development Authority, Government of Karnataka, Karwar, Karnataka, 5-7 May 2016; 9-11 May 2016

Hindi workshop at Mangalore Research Centre, 29 June 2016

Workshop on 'Scientific Cooperation Framework for Food', New Delhi, 12 July 2016

Hands-on training organized by Department of Fisheries, Mangalore and MRC of ICAR-CMFRI on green mussel seeding, oyster ren fabrication and hygienic shucking of edible oysters, Mulki, Karnataka, 21-22 July 2016

National Workshop on 'Sustainable Aquaculture Production Systems' Kochi, Kerala, 22-24 July 2016

Meeting with the Kerala State Fisheries Department officials at Office of the Deputy Director of Fisheries, Kasaragod, Kerala, 14 October 2016

Mussel farmer's and agent's awareness programme, Kasaragod, Kanhangad and Valiyaparamba Panchayat, 15 October 2016

Training programme on cage culture of finfish and bivalve farming organised by Department of Fisheries, Mangalore and MRC of ICAR-CMFRI, Mangalore, Mulki, 18-19 November 2016

Exhibition in connection with the Kisan Mela and Mega-Exhibition-Centenary Expo at CPCRI Kasaragod, 10-12 December 2016

Resource person for training Programme on bivalve farming organised by MRC of CMFRI, Mangalore and Department of Fisheries, Sasthan, Saligrama, 23 December 2016

Resource person for the HRD training for Sub Inspectors of Fisheries, at Training Centre, Kerala State Fisheries Department, Government of Kerala, East Kadungallore, Kerala, 20 June, 2016; 27 February 2017

'Matsya Mela 2017' organised by MRC of CMFRI, Malpe Beach, Udupi District, 3-5 March 2017

Dr. Geetha Sasikumar, Dr. Shoba Joe K. Kizhakudan, Dr. V. Venkatesan, Smt. M. Muktha, Dr. L. Ranjith, Mr. Vivekanand Bharti and Dr. S. Gomathy Training programme on Essential Ecosystem Approach to Fisheries Management: Developing Capacity in the Ecosystem Approach to Fisheries Management, CMFRI, Kochi, 30 August-3 September 2016

Dr. I. Jagadis 12th Scientific Advisory Committee meeting (hosted by SCAD), Krishi Vigyan Kendra, Vagaikulam, Thoothukudi, 7 September 2016

Dr. I. Jagadis and Shri. C. Kalidas Meeting on selection of beneficiary group for undertaking cage culture of cobia and lobsters, Sippikulam, 18 July 2016

Technical meeting under the project Fisheries Management for sustainable livelihood (FIMSUL), State Fisheries Department, Tuticorin, 13 December 2016

Smt. F. Jasmin Interactive workshop on Philosophy, Methods and Ethics in Science, Visakhapatnam Regional Centre of CMFRI, Visakhapatnam, 22-24 March 2016

Dr. R. Jayakumar Board of Studies Meeting in the Department of Marine Biotechnology, Bharathidasan University, Trichy, Tamil Nadu, 9 December 2016

Working group meeting on preparation of draft Policy document for development of Mariculture in India Kochi, 16-17 January 2017.

International Conference on Profit on Aquaculture-2017. The UAR Foundation, Bhimavaram, SV University, Tirupathi and Asian Institute of Technology, Thailand held at Shri Vishnu Educational Academy, Bhimavaram, Andhra Pradesh, 11-14 February 2017

Dr. R. Jeyabaskaran National launch workshop of Dugong project, Wildlife Institute of India, Dehradun, 16 May 2016

Conference on management and conservation of seagrass ecosystem in India organized by MoEFCC and GIZ CMPA, India Habitat Centre, New Delhi, 12-13 July 2016

National Seminar on Marine resources utilization, exploitation and conservation, Department of Zoology, A.P.C. Mahalaxmi College for Women,Tuticorin, 23 August 2016

Dr. Joe K Kizhakudan 49th Institute Management Committee meeting of ICAR-CIBA, Chennai, 27 January 2017

Mariculture stakeholders meeting with the members of the Association of Progressive Fishermen (AKPF) to review cage farming activities, Kovalam, Chennai, 28 June 2016

Skill development training programme on sea cage farming for fisher youth of coastal fishing villages in Kancheepuram District, Kovalam , Chennai, 9-10 September 2016

Stakeholders meeting on Non-detriment findings on CITES listed species of sharks and rays, Madras Research Centre of CMFRI, Chennai, 27 August 2016

Skill development training programme on sea cage farming for fisher youth of coastal fishing villages in Thiruvallur District of Tamil Nadu, Senjiamman Nagar, Pazhaverkadu, 17-18 January 2017

Workshop on Intensive Pond Aquaculture Technology (IPAT) conducted by the USSTEC, Visakhapatnam, 17 May 2016

48th Institute Management Committee meeting of ICAR-CIBA, Chennai, 18 June 2016

Dr. Joe K Kizhakudan and Dr. R. Geetha Mariculture stakeholders' meetings with the fisher youth boys of Kovalam (AKPF), Kovalam, Chennai, April and May 2016.

Dr. B. Johnson Partners Meet organized by Reliance Foundation, Ramanathapuram, 15 June 2016

Impact Assessment of Agricultural Extension, National Academy of Agricultural Research Management (NAARM), Hyderabad, 6-10 June 2016

Fishermen Grievance Meeting, Ramanathapuram District Administration, 23 September 2016

Dr. B. Johnson and Dr. R. Saravanan Training of Trainers on 'Participatory methods of training delivery for curriculum on coastal and marine biodiversity Goa, 15-18 November 2016

Dr. K. K. Joshi, Dr. K. S. Sobhana, Dr. M. K. Anil, Dr. B. Santhosh, Dr. S. Jasmine, Dr. Molly Varghese, Dr. Rekha J. Nair, Dr. Sandhya Sukumaran, Dr. Grinson George, Dr. Jayasree Loka, Dr. K. R. Sreenath, Dr. Raju Saravanan, Dr. L. Ranjith, Dr. N. S. Jeena 1st International Agrobiodiversity Congress (IAC 2016), Indian Society of Plant Genetic Resources and Biodiverisy International, New Delhi, 6 - 9 November 2016

Dr. Kajal Chakraborty Review meeting of Ministry of Earth Sciences (MoES) sponsored program "Drugs from sea", Hotel Ella, Hyderabad, 9-10 April 2016

Review Meeting of CRP on Health Foods, ICAR-CIPHET, Ludhiana, 17 September 2016

Review meeting of MoES network project on Drugs from the Sea, CSIR-CDRI Lucknow, 6 March 2017

Review meeting of ICAR CRP project on Health Food at the two day Annual Meeting-cum-Workshop at ICAR-CIPHET Ludhiana,10 March 2017

Meeting to out-license the nutraceutical product Cadalmin™ Antidiabetic extract (ADe) to Celestial Biolabs Ltd, Hyderabad, CMFRI, Kochi, 24 April 2017

Dr. Kajal Chakraborty and Dr. T.G. Sumithra 26th Swadeshi Science Congress,CMFRI, Kochi, 7-9 November 2016

Shri C. Kalidas Meeting on NADP-FIMSUL-Fisheries management for sustainable livelihoods. Department of Fisheries, Tuticorin, 18 July 2016

Fisherman meet under ATMA programme, State Fisheries Department, Tuticorin, 10 January 2017

Shri. C. Kalidas, Shri Pralaya Ranjan Behera and Dr. Sekar Megarajan National seminar on Aquaculture Diversification: The way forward for blue revolution (NaSAD-2016), CIFA, Bhubaneswar, Odisha, 1-3 December 2016

Dr. V. Kripa Doctoral Committee meeting of Mangalore University, Mangalore, 20 April 2016

RAC Meeting of INCOIS, Hyderabad, 12 May 2016

RAC Meeting of CMLRE, Kochi, 31 June 2016

International Maritime Seminar, K.M. School of Marine Engineering, CUSAT, 5 August 2016

Seminar conducted by the Punnapra Fishermen Development and Co-operative Society, Kakkazham, Alappuzha, 5 September 2016

Seminar on 'Periyar and Drinking water' organized by the Kerala Grama Swaraj Foundation, Ernakulam, 8 September 2016

Inaugural meeting of cleaning programme of Cochin backwaters conducted by Dheewara Sabha, Kochi, 2 October 2016

Seminar conducted by Kerala Naree Samrakshana Samathi, St. Teresa's College, Kochi, 3 October 2016

Seminar conducted by Matsyafed Employees Federation, Kannur, 6 November 2016

Inaugurated World Wetland day Celebration at Sree Narayana College, Cherthala, 2 February 2017

Training on stitching of eco-friendly carry bags for women and students organised in collaboration with St. Mary's College, Thrissur, 7 February 2017

Academic Council meeting of KUFOS, Kochi, 13 February 2017

World wetlands day celebration at Maharajas College, Ernakulam, 14-15 February 2017

Dr. V. Kripa, Dr. P.S. Asha, Dr. Shelton Padua, Smt. P. Hemasankari and Shri. K. Diwakar Training cum workshop on Methods of Ecological Analysis using Statistical Software, CMFRI, Kochi, 5-11 January 2017

Dr. V. Kripa, Dr. Kajal Chakraborty and Dr. Shelton Padua First working group meeting on Marine oil spill and its impact on marine ecosystem, CMFRI, Kochi, 8 July 2016

Dr. V. Kripa, Dr. M. Sivadas, Dr. S. Lakshmi Pillai Meeting on Third party evaluation of NICRA project, CMFRI, Kochi, 18 - 19 January 2017

Dr. V. Kripa, Dr. Shyam S. Salim, Dr. V.P. Vipinkumar, Dr. Somy Kuriakose, Dr. Rekha J. Nair, Dr. K.G. Mini, Dr. Miriam Paul Sreeram, Dr. M.A. Pradeep, Dr. P. Shinoj, Smt. J. Reshma, Dr. T.G. Sumithra, Dr. Livi Wilson Served as Resource person for the training programme: Theeranaipunya-II, Skill enhancement and capacity development of fisher youth, CMFRI, Kochi, 3 February 2017.

Dr. S. Lakshmi Pillai Workshop on Ecosystem Approaches to Fisheries Management organised by BOBP and CMFRI, CMFRI, Kochi, 26-30 August 2016

Dr. P. Laxmilatha Convened interactive meeting between scientist of MRC of CMFRI Chennai and stakeholders from Thiruvallur Chennai Kanchipuram, Villupuram and Cuddalore districts, MRC of CMFRI, Chennai, 19 April 2016

Inception meeting for the project on IFMR LEAD Office, Chennai, 4 July 2016

Meeting convened by the Commissioner of Fisheries, Chennai in connection with implementation of the project-World Bank assisted Coastal Disaster Risk Reduction Programme, Department of Fisheries, Tamil Nadu, Chennai, 8 July 2016

Meeting held between Fisheries Department and CMFRI for technical and field level collaboration for FIMSUL Scheme, Commissionerate of Fisheries, Department of Fisheries, Chennai, 13 July 2016

Organized the Hindi Workshop, MRC of CMFRI Chennai, 30 August 2016

Organized training for Youth of Kancheepuram District on open sea cage Farming, Kovalam, Chennai, 9-10 September 2016

Stakeholder and consultation meeting in connection with the action to be taken during the nesting and breeding season of sea turtles which commences from January 2017. Office of Commissionerate of Fisheries, Chennai, 7 November 2016

24th FSI meeting in connection with implementation of the survey programme 2016-17 by the base and the proposed survey programme for the year 2017-18. Commissionerate of Fisheries, Department of Fisheries, Chennai, 1 February 2017

Organised the Hindi workshop on "Uses of Hindi in daily life", MRC of CMFRI, Chennai, 28 March 2017

Dr. P. Laxmilatha and Dr. P.P. Manojkumar 25th meeting of ICAR Regional Committee VIII, Tamil Nadu Agricultural University, Coimbatore, 11-12 November 2016

Dr. P. Laxmilatha and Ms. E.M. Chanda Prajanadarsini ISRO Sponsored NNRMS certificate course on Remote Sensing and Geographical Information System Applications in Coastal and Ocean Sciences, Indian Institute of Remote Sensing, Dehradun, 2 May - 24 June 2016

Dr. P. Laxmilatha and Dr. Shoba Joe Kizhakudan Stakeholders consultation meet, Commissionerate of Fisheries, Department of Fisheries, Chennai, 29 July 2016

3rd State Level Technical Committee Meeting, Commissionerate of Fisheries, Department of Fisheries, Chennai, 19 October 2016

Discussion with the FIMSUL - II World Bank expert Dr. Martin Kumar in connection with the project activities and reviewing the progress of Implementation of the various activities, Commissionerate of Fisheries, Department of Fisheries, Chennai, 18 January 2017

Smt. Livi Wilson Professional Attachment Training, CSIR-National Institute of Oceanography, Kochi, 30 May-30 August 2016

Fish and shell fish taxonomy training, CMFRI, Kochi, 19 September-25 October 2016

Training in Fishery Resources Assessment Division (FRAD), Kochi, 1 December 2016-28 February 2017

Dr. L. Loveson Edward Stakeholders meeting of Fishery and Aquaculture Industry, MPEDA, Bhimavaram, India, 15 July 2016

Andhra Pradesh state Biodiversity Board meeting, Hyderabad, 9 August 2016; 11 February 2017

Dr. M.S. Madan, Dr. S.S. Raju and Dr. R. Geetha Methodology workshop on valuation and impact studies, CMFRI, Mandapam, 1-2 September 2016

Dr. G. Maheswarudu Book release (First Food : Culture of Taste) by Sunita Narain, Director General, Centre for Science & Environment Pavillion, Cabral Yard, Fort Kochi, 15 March 2017

Dr. G. Maheswarudu and Dr. Josileen Jose Stakeholders workshop on Kerala State Fisheries, CMFRI, Kochi, 9 September 2016

Dr. G. Maheswarudu and Dr. P.P. Manojkumar Meeting of the Working Group on Preparation of Mariculture Policy for India, CMFRI, Kochi, 16-17 December 2016

Dr. P.P. Manojkumar Training on Management Development Programme for Leadership Development (a pre-RMP programme) NAARM, Hyderabad, 19-30 December 2016

Dr. P.P. Manojkumar, Dr. Shoba Joe Kizhakkudan Dr. Sujitha Thomas, Dr. Rekha J. Nair , Dr. T.M Najmudeen, Smt. M. Muktha and Dr. K.V. Akhilesh National Workshop for preparation of NDF Document on CITES listed elasmobranch species, CMFRI, Kochi, 12-16 July 2016

Dr. P.P. Manojkumar, Dr. P. Laxmilatha and Dr. Joe K Kizhakudan Meeting for preparing a project proposal for Tamil Nadu Fisheries Department under the Fisheries Management for Sustainable Livelihoods-II Project (FIMSUL II) CMFRI, Kochi, 10-16 August 2016

Dr. P.P. Manojkumar and Dr. I. Jagadis Meeting on Expert Consultation on Revitalising Indian Fisheries Education, Fisheries College & Research Institute, Tuticorin, 17 June 2016

Scoping consultation on Characterisation of Tuna Fisheries in India under the Partnership project of BOBP-IGO, Hotel GRT Regency, Tuticorin, 22 September 2016

Dr. Margaret Muthu Rathinam Tender Scrutiny and Evaluation Committee (TS & EC) meeting on 'Development of world class Oceanarium at Mamallapuram under PPP basis' Department of Fisheries, Tamil Nadu, Chennai, 31 August 2016

Dr. K.S. Mohamed Fourth meeting of the committee constituted to suggest Draft National Policy on Marine Fisheries at New Delhi, 4 May 2016

1st International Training Workshop on Taxonomy of Bivalve Molluscs (ITW 01), CUSAT, Kochi, 10 May 2016

Fifth meeting of the committee constituted to suggest Draft proposal of National Policy on Marine Fisheries, New Delhi, 1 June 2016

Meeting on National Policy on Marine Fisheries, Krishi Bhavan, New Delhi, 9-10 June 2016

Consultative meeting on Biodiversity Beyond National Jurisdiction (BBNJ), CMLRE, Kochi, 22 June 2016

GIZ-BOBP National Workshop on Dissemination of study results of valuation studies on coastal and marine ecosystem under the TEEB India Initiative, Chennai, 27 June 2016

Meeting to discuss various issues related to the project on Commercial Pearl Production in A & N Islands, Port Blair, 29 June 2016

Fisheries Code meeting, CMFRI, Kochi, 2-4 July 2016

Fisheries Consultative meeting at CMFRI, Kochi, 7 July 2017

Seminar on 'Prospective Aquaculture Plan of Kerala', Kollam, 9 July 2016

Sixth meeting of the committee constituted to suggest Draft National Policy on Marine Fisheries, New Delhi, 21 July 2016.

Meeting to discuss the issues relating to use and regulation of LED lights (Light Emitting Diode) in fishing vessels at Krishi Bhavan, New Delhi, 16 August 2016

Resource person for handling a session on "Minimum Legal Size and Stock Depletion" in the Awareness Programme of Fishermen of Ernakulam District organized by Department of Fisheries, Kerala at the Relief Boat Owners Association Hall, Munambam, 20 October 2016

Meeting of the Working Group on Fisheries at State Planning Board, Pattom, Trivandrum, 27 October 2016

Third meeting of the Expert Committee for making amendments in KMFR Act, CIFT, Kochi, 31 October 2016

Awareness programme for fishermen of Ernakulam District as faculty at Thoppumpadi, 7 November 2016

Meeting with Minister of Fisheries, Trivandrum, 10 November 2016

Meeting on Clam restoration project in Vembanad Lake, CMFRI, Kochi, 17 December 2016

Regional level workshop of the Expert Committee of the KMFR act and rules - amendments, Kozhikode, 16 January 2017

One day leadership study campaign in connection with the Kerala Pradesh Matsyathozhilali Congress, Trissur District, Thriprayar, Thrissur, 4 February 2017

State level workshop of the Expert Committee of the KMFR act and rules - amendments, CMFRI, Kochi, 14 February 2017

UGC sponsored National Seminar on Marine Ecosystem Health organized by Dept of Marine Biology, Microbiology and Biochemistry, CUSAT, 16-17 March 2017

Stakeholder Meeting regarding Fishery Improvement Project organized by C.P. Aquaculture (India) Pvt Ltd., Kochi, 24 March 2017

National Seminar on Mitigating juvenile incidence in fishing - the way forward and delivered a talk on Resource status of juvenile incidence in Indian seas, CIFT, Kochi, 25 March 2017

Dr. K.S. Mohamed, Dr. P.U Zacharia, Dr. G. Maheswarudu,Dr.R. Narayakumar, Dr. T.V.Sathianandan, Dr. K. K. Joshi, Dr. Imelda Joseph, Dr. E.M. Abdussamad, Dr. Josileen Jose, Dr. J. Jayasankar, Dr. C Ramachandran, Dr. V.P. Vipinkumar, Dr. Rekha J. Nair, Dr. S. Lakshmi Pillai, Dr. U Ganga, Dr. Somy Kuriakose, Dr. K.G. Mini, Dr. N. Aswathy, Dr. P. Shinoj, Shri. Bhendekar Santosh, Shri. R. Vinoth kumar, Shri. Ambarish P. Gop, Shri. Vivekanand Bharti and Dr. Livi Wilson Stakeholder workshop for Kerala, 21 April 2016

Dr. K.S. Mohamed, Dr. G. Maheswarudu, Dr. Josileen Jose and Dr. S. Lakshmi Pillai Brainstorming workshop on Effective Implementation of Minimum Legal Size (MLS) in Fisheries, Kerala, organized by Network for Fish Quality Management and Sustainable Fishing (NETFISH), CMFRI, Kochi, 26 August 2016

Dr. K.S. Mohamed, Dr. G. Maheswarudu, Dr. T.V. Sathianandan, Dr. M. Sivadas, Dr. J. Jayasankar, Dr. S. Lakshmi Pillai, Dr. Somy Kuriakose, Dr. K.G. Mini, Dr. V. Venkatesan, Dr. Grinson George, Smt. M. Muktha, Mr. Vinay Kumar Vase and Mr. Vivekanand Bharti Workshop on Advances in Fish Stock Assessment Methods organized by FRA Division, CMFRI, Kochi, 15-17 November 2016

Dr. K.S. Mohamed, Dr. V. Kripa, Dr. T.V. Sathianandan, Dr. J. Jayasankar, Dr. Somy Kuriakose, Dr. K.G. Mini, Dr. Grinson George, Dr. Sandhya Sukumaran, Shri. C. Kalidas and Smt. M. Kavitha International Conference on Science and Technology for National Development, Kerala University of Fisheries and Ocean Sciences (KUFOS), Panangad, Kerala, 25-26 October 2016 Dr. K.S. Mohamed and Dr. V. Kripa-Meeting of the Ashtamudi Lake Clam Governance Council, Kollam, 22 November 2016

Dr. K.S. Mohamed, Dr. V. Kripa, Dr. G. Maheswarudu, Dr. T.V. Sathianandan, Dr. M. Sivadas, Dr. J. Jayasankar, Dr. S. Lakshmi Pillai, Dr. Somy Kuriakose, Dr. Rekha J. Nair, Dr. K.G. Mini, Dr. T.M. Najmudeen, Dr. Grinson George and Vivekanand Bharti FMP project review workshop - Meeting on finalization of FMP projects. CMFRI, Kochi, 18-20 December 2016

Dr. K.S. Mohamed,Dr. D. Prema and Smt. I. Santhosi National Workshop on Mud Banks of Kerala: Status, issues and societal concerns organized by CSIR-NIO Regional Centre, Kochi, 10-11 February 2017

Smt. M. Muktha Consultative Group Meeting at FSI Visakhapatnam, 11 January 2017

Dr. M. A. Pradeep Review Meeting on National surveillance programme for aquatic animal diseases' (NSPAAD), Bengaluru, 16-17 June 2016

Annual review workshop of AMAAS, at NASC complex, New Delhi, 7-8 July 2016

Meeting of the Technical Committee for genomic selection of breeding bulls-Kerala Livestock Development Board, Pattom, Trivandrum, 13th January 2017

Meeting on CRP on vaccine and Diagnostics, CIBA Chennai, 16 November 2016

Dr. D. Prema Out Reach program organized by the Social Work Department of Lisie Hospital in association with Kochi Municipal Corporation, Lisie Hospital, Kochi, 21 March 2017

Dr. S.S. Raju Orientation training on CMFRI, Kochi, India, 2-7 May 2016

Review meeting on regional crop planning for improving resource use efficiency and sustainability, ICAR NIAP, New Delhi, 24-25 June 2016

Meeting on forum on fisheries professionals, CIFT, Visakhapatnam, 15 July 2016

India Norway workshop on fish trade related international requirements, Port trust Diamond Jubilee Stadium, Visakhapatnam, 25 September 2016

Policy advocacy and dissemination workshop on regional crop planning, MPKV, Rahuri, 22 December 2016

Concluding meeting on regional crop planning for improving resource use efficiency and sustainability, ICAR NIAP, New Delhi, 24-25 March 2017

Dr. S.S. Raju, Smt. M. Muktha and Smt. F. Jasmin Stakeholder workshop, RC of CMFRI, Visakhapatnam, 13 April 2016

Dr. S.S. Raju, Dr. L. Loveson Edward, Smt. M. Muktha, Smt. F. Jasmin Stakeholder consultation meeting on the National Marine Fisheries Policy Conducted by the Joint Director (Fisheries), Govt. of Andhra Pradesh, CIFNET, Visakhapatnam, 20 April 2016

Shri. Rajesh Kumar Pradhan Stakeholders' consultation meeting for finalization of Non-Detriment Findings(NDF) report on selected 5 sharks and 2 rays species that have been enlisted in the CITES appendix II, Veraval, 2 September 2016

Served as Chairman of Farmers delegation and liaison team on the conduct of "SamudriyaKrishi Mela-2016" an exhibition cum farmers meet at Veraval Research Centre of CMFRI, 22 April 2016

Dr. L. Ranjith Public consultation meeting on Environmental Impact Assessment (EIA) & Social Impact Assessment (SIA) for the Tuticorin Outer Harbour Development of V.O.C. Port Trust funded by Japan Internation, Tuticorin, 28 July 2016

Stakeholders Consultation Meeting and Technical Committee meeting on Squid Jigging, Kanyakumari, 19 October 2016

Meeting on Coral reef ecosystem and management, St. Mary's College, Tuticoin, 31 March 2017

Dr. Rekha J Nair Faculty training programme on "Species Identification" conducted as a part of Component – III of Fisheries Management for Sustainable Livelihood (FIMSUL), Phase II, supported by the World Bank and implemented by the Department of Fisheries, Government of Tamil Nadu. ICAR-CMFRI, Kochi, 20 March - 1 April 2017

Dr. Ritesh Ranjan Good Aquaculture Practices and Food Safety Preventative Control for Aquaculture Farms, Visakhapatnam, 17-18 November 2016

Dr. Sandhya Sukumaran Hands-on training on Next Generation Sequence Data analysis. ICAR-CIFA, Bhubaneswar, 6-12 December 2016

Group Monitoring workshop conducted by DST-SERB, KIIT University, Bhubaneswar, Odisha, 2 February 2017

Dr. Sandhya Sukumaran, Dr. M. A. Pradeep and Smt. J. Reshma Training programme on Exploring Gene Expression Data using Transcriptome and Micrarrays, Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram, 18-20 April 2016

Dr. N. K. Sanil Meeting of the sub-committee to Review and update the guidelines for import of ornamental fishes, Krishi Bhavan, New Delhi, 11 April, 2016

Second meeting of the Expert committee to develop technical design for construction of Aquatic Animal Quarantine Units (AAQU) and Disease Diagnostic Laboratories (DDL), at Krishi Bhavan, New Delhi, 6 May 2016

Annual meeting of National Surveillance Programme for Aquatic Animal Diseases (NSPAAD), NBFGR, Lucknow, 27-29 May 2016

Meeting of the NSPAAD Core Committee,NBFGR, Lucknow, 27 May 2016

Annual meeting of CRP on Diagnostics & Vaccines, IVRI Bangalore, 16-17 June 2016

19th meeting of the National Committee on Introduction of Exotic species into Indian Waters, Krishi Bhavan New Delhi, 24 June 2016

Meeting of the sub-committee to Review and update the guidelines for import of ornamental fishes, Krishi Bhavan, New Delhi, 29 July 2016

Third meeting of Expert committee to develop technical design for construction of aquatic Animal Quarantine Units (AAQU) and Disease Diagnostic Laboratories (DDL), Chennai, 9 August 2016 .

Training/workshop for Nodal Officers of Public Authorities, NAARM, Hyderabad, 25 October 2016

Interactive meeting on National Action Plan for Antimicrobial Resistance with reference to Aquaculture/Fisheries, New Delhi, 27 December 2016

21st meeting of the National Committee on Introduction of Exotic Aquatic Species into Indian Waters, New Delhi, 24 March 2017

Dr. T.V. Sathianandan, Dr. Somy Kuriakose and Dr. Grinson George Consultative Meeting of Fisheries Institutes organised by the Department of Fisheries, Government of Kerala, ICAR-CMFRI, Kochi, 7 July 2016

NICRA review workshop, CMFRI, Kochi, 18 January 2017

Dr. Shelton Padua Session on identification and mapping of paddy and wetlands using Geospatial Technologies for the Assistant Directors and Agricultural Officers, Department of Agriculture, Collectorate Conference Hall, Kakkanad, 16 July 2016

Training programme on fish and shellfish taxonomy, CMFRI, Kochi, 19 September-15 October 2016

Training programme on Geospatial Analysis for Natural Resource Management,NAARM, Hyderabad, 18-27 October 2016

ESRI India GeoVision Seminar, Trivandrum, 9 December 2016

Dr. Shelton Padua, Dr. R. Vidya, Dr. K.V. Akhilesh and Mr. Vinay Kumar Vase NICRA sponsored training programme on Monitoring Structure and Function of Pelagic Ecosystem at Regional Sectors: Relevance for Fisheries, CMFRI, Kochi, 16 November to 6 December 2016

Dr. Shoba Joe Kizhakudan Stakeholder consultation on NDF for CITES Appendix II listed species of sharks and manta rays, MRC of CMFRI, Chennai, 27 August 2016

Dr. Shoba Joe Kizhakudan and Dr. Rekha J Nair NICRA documentation workshop on species vulnerability assessment CMFRI, Kochi, 13 - 15 June 2016

Dr. Shoba Joe Kizhakudan, Dr. S. Lakshmi Pillai and Dr. Rekha J Nair NICRA review workshop, CMFRI, Kochi, 18 January 2017

Dr. Shubhadeep Ghosh Meeting on Tuna and tuna-like fishes of the Indian Ocean BOBP, Chennai, 16 April 2016

Meeting of the Project Coordination Committee of the World Bank-GEF Project on Ocean Partnerships for Sustainable Fisheries and Biodiversity Conservation-Models for Innovation and Reform, BOBP, Chennai, 2 June 2016

Regional workshop on Fisheries Management in the context of Highly Migratory Fish Stocks, BOBP, Chennai, 4 June 2016

Regional Committee Zone 2 meeting, NAARM, Hyderabad, 24-25 June 2016

Ecosystem valuation, BOBP and MOEF&CC, Chennai, 27-28 June 2016

AINP Review meeting, NAAS, New Delhi, 3-4 November 2016

Meeting on Marine fish Stock Status with Secretaries of the Department of Agriculture and Department of Commerce, Krishi Bhavan and Udyog Bhanan, 9 November 2016

Meeting on Climate change and fisheries, Commissioner of Fisheries, DAHDF and DDG (Fisheries), New Delhi, 19-20 December 2016

Dr. M. Sivadas Scoping Consultations on Tuna Fisheries in India, BOBP-IGO, Chennai, 21 July 2016

Dr. K.S. Sobhana, Dr. Krupesha Sharma, Dr. Sandhya Sukumaran, Dr. M. A. Pradeep Smt. J. Reshma, Dr. N.S. Jeena and Dr. T.G. Sumithra NextGen Genomics, Biology, Bioinformatics and Technologies (NGBT) Conference 2016, organised by M/s SciGenom Research Foundation (SGRF) India, Kochi, 3-5 October 2016

Dr. Somy Kuriakose XVIII National Conference of Agricultural Research Statisticians at Indian Institute of Farming System Research, Modipuram, 16 December 2016

Dr. C.P. Suja Research Board Meeting Manonmaniam Sundaranar University, Tirunelveli, 21 December 2016; 20 January 2017

Dr. T.G. Sumithra International symposium on microbial ecology and systematics, CSIR-National Chemical Laboratory, Pune,16-17 September 2106

Dr. V. Venkatesan Organised training to the staff from Tamil Nadu State Fisheries Department,CMFRI, Kochi, 30-31 March 2017

Dr. R. Vidya Served as Resource Person for the Orientation programme for National Children Science Congress, Kendriya Vidyalaya, Port Trust, Kochi, 5 August 2016

Dr. P. Vijayagopal Interaction session with Mr. James Davis, Lead (Offshore Logistics and Operations) and Mr. Richard McMullan, Lead (Programme Delivery & Compliance) from International consultancy group Eco fish, CMFRI, Kochi, 20 March 2017

Dr. K .Vijayakumaran Conducted an Interactive Co-Learning Workshop on Philosophy, Methods and Ethics in Science, Central Institute of Freshwater Aquaculture (CIFA), Bhubaneshwar, 26-28 May 2016

Mr. Vinay Kumar Vase Stakeholder consultation on the draft Non-Detriment Finding (NDFs) for enlisted 5 sharks and 2 manta rays species in the CITES Appendix II, Regional Centre of CMFRI, Veraval, 29 August 2016

Served as Resource Person for the Industrial Work Experience Training Programme for the Diploma students from College of Fisheries, DBSKKV, December 2015-April 2016, Dapoli

Inception Workshop for the CMFRI-SAC Collaborative Project on Remote sensing & GIS for Ecosystem based marine living resources management, Veraval RC of CMFRI, 8-10 November 2016

Training programme on Open Sea Cage Farming, Veraval RC of CMFRI, 6 February 2017; 6 March 2017

Stakeholder consultation on the Tuna Fisheries along Gujarat in collaboration with Bay of Bengal Programme-Inter-Governmental Organization (BOBP-IGO) under the programme Ocean Partnership for Sustainable Fisheries and Biodiversity Conservation - Models for Innovation and Reforms, Veraval, Gujarat, 22 October 2016

Advances in Experimental Data Analysis under the aegis of Centre of Advanced Faculty training, ICAR-IASRI, New Delhi, 6-26 October 2016

International Conference on Climate change Adaptation and Biodiversity: Ecological Sustainability and Resource Management for Livelihood Security, CIARI, Port Blair, 8-10 December 2016

National Seminar on Mitigating Juvenile Incidence in Fishing, ICAR-CIFT, Kochi, 25 March 2017

Mr. Vinay Kumar Vase and Shri. Rajesh Kumar Pradhan Stakeholder's consultation on the Tuna Fisheries along Gujarat in collaboration with Bay of Bengal Programme-Inter-Governmental Organization (BOBP-IGO), 22 October 2016, Veraval, Gujarat

Inception workshop on Artificial Fish Habitat Based Marine Ecosystem Restoration in the Inshore Areas off Bhadreswar, Kutch District, Gujarat, Bhadreswar, 18 January 2017

Dr. P.U Zacharia, Dr. G. Maheswarudu, Dr. R. Narayakumar, Dr. K. K. Joshi,Dr. P.P. Manojkumar, Dr. E.M. Abdussamad, Dr. Shoba Joe Kizhakkudan, Dr. Sujitha Thomas, Dr. Rekha J. Nair, Dr. T.M Najmudeen, Dr. N.Aswathy and Dr. K.V. Akhilesh Stakeholder consultation on the draft Non Detriment Finding (NDFs) for enlisted 5 sharks and 2 manta rays species in the CITES Appendix II, CMFRI, Kochi, 8 September 2016

Deputation Abroad

Dr. A. Gopalakrishnan, Dr. Imelda Joseph, Dr. Somy Kuriakose, Dr. Rekha J. Nair and Dr. Grinson George 11th Asian Fisheries and Aquaculture Forum (AFAF), Bangkok, Thailand, 3-7 August 2016

Dr. Grinson George International Workshop on Colour and Light in the Ocean from Earth Observation (CLEO), ESA-ERSIN, Frascati, Rome, Italy, 6 - 8 September 2016

Dr. Rekha J. Nair IUCN Red List Training and Grouper Re-assessment Workshop, Horta, Azores, Portugal, 15-22 November 2016

Dr. K. S. Mohamed Marine Stewardship Council's Technical Advisory Board (TAB) meeting, London, U.K., 29-30 November 2016

Dr. V. Kripa Scoping meeting of the IPCC Special Report on Climate Change and Oceans and Cryosphere, Monaco, 6-9 December 2016

Dr. K.V. Akhilesh Red List Assessment Workshop of Sharks, Rays and Chimaeras in the Arabian Sea and its Adjacent Waters, Abu Dhabi, UAE, 5 - 9 February 2017

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CMFRI

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

Headquarters

KOCHI Post Box No. 1603, Ernakulam North P.O.
Kochi-682 018, Kerala, India
Tel: +91-484-2394867 Fax: +9-484-2394909
E-mail: director@cmfri.org.in
www.cmfri.org.in

Regional Centres

MANDAPAM Marine Fisheries P.O.
Mandapam Camp-623520
Tel: 04573-241433, 241456 Fax: 04573-241502
E-mail: mandapam@cmfri.org.in

VISAKHAPATNAM Pandurangapuram
Ocean View Layout, Visakhapatnam-530003
Andhra Pradesh Tel: 0891-2543797, 2543793
Fax: 0891-2500385
E-mail: vizag@cmfri.org.in

VERAVAL Matsya Bhavan
Bhidia Veraval-362269, Gujarat
Tel: 02876-232649, Fax: 02876-231865
E-mail: veraval@cmfri.org.in

Research Centres

MUMBAI 2nd Floor, CIFE (Old campus) Fisheries
University Road, Versova, Mumbai-400 061
Maharashtra Tel: 022-26392975/26393029
Fax: 022-26320824
E-mail: mumbai@cmfri.org.in

KARWAR PB No.5, Karwar-581301
North Kanara, Karnataka
Tel: 08382-222639 Fax: 08382-221371
E-mail: karwar@cmfri.org.in

MANGALORE Technology Wing Campus of College of Fisheries, P.B.No. 244
Hoige Bazar Mangalore-575 001
Dakshina Kannada, Karnataka
Tel: 0824-2424152, Fax: 0824-2424061
E-mail: mangalore@cmfri.org.in

CALICUT West Hill PO, Calicut-673005
Tel: 0495-2382033, 2382011, 0495-2382011
E-mail: calicut@cmfri.org.in

VIZHINJAM P.B. No. 9, Vizhinjam P.O.
Thiruvananthapuram-695521, Kerala
Tel: 0471-2480224, Fax: 0471-2480324
E-mail: trivandrum@cmfri.org.in

TUTICORIN South Beach Road (Near Roche Park)
Tuticorin 628001, Tamil Nadu
Tel: 0461-2320274, 2320102 Fax: 0461-2322274
E-mail: tuticorin@cmfri.org.in

CHENNAI 75, Santhome High Road
Raja Annamalaipuram, Chennai-600028, Tamil Nadu
Tel: 044-24617264/24617317
Fax: 044-24617290
E-mail: chennai@cmfri.org.in

DIGHA 14 Miles, Near Benfish, Ramnagar-721441
Dist. East Mednipur, West Bengal
Tel: 03220-264050 Fax: 03220-264040
Email: digharccmfri@gmail.com

Krishi Vigyan Kendra

Arattuvazhi Beach, Narakkal P.O.
Ernakulam 682505. Kerala
Email: kvkernakulam@yahoo.co.in
www.kvkernakulam.org.in

Indian Council of Agricultural Research
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
Post Box No.1603, Ernakulam North P.O., Cochin-682 018, Kerala, India
Tel: +91 484 2394867 Fax: +91 484 2394909 E-mail: director@cmfri.org.in, www.cmfri.org.in